S. A. E. JOURNAL

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News of the Society

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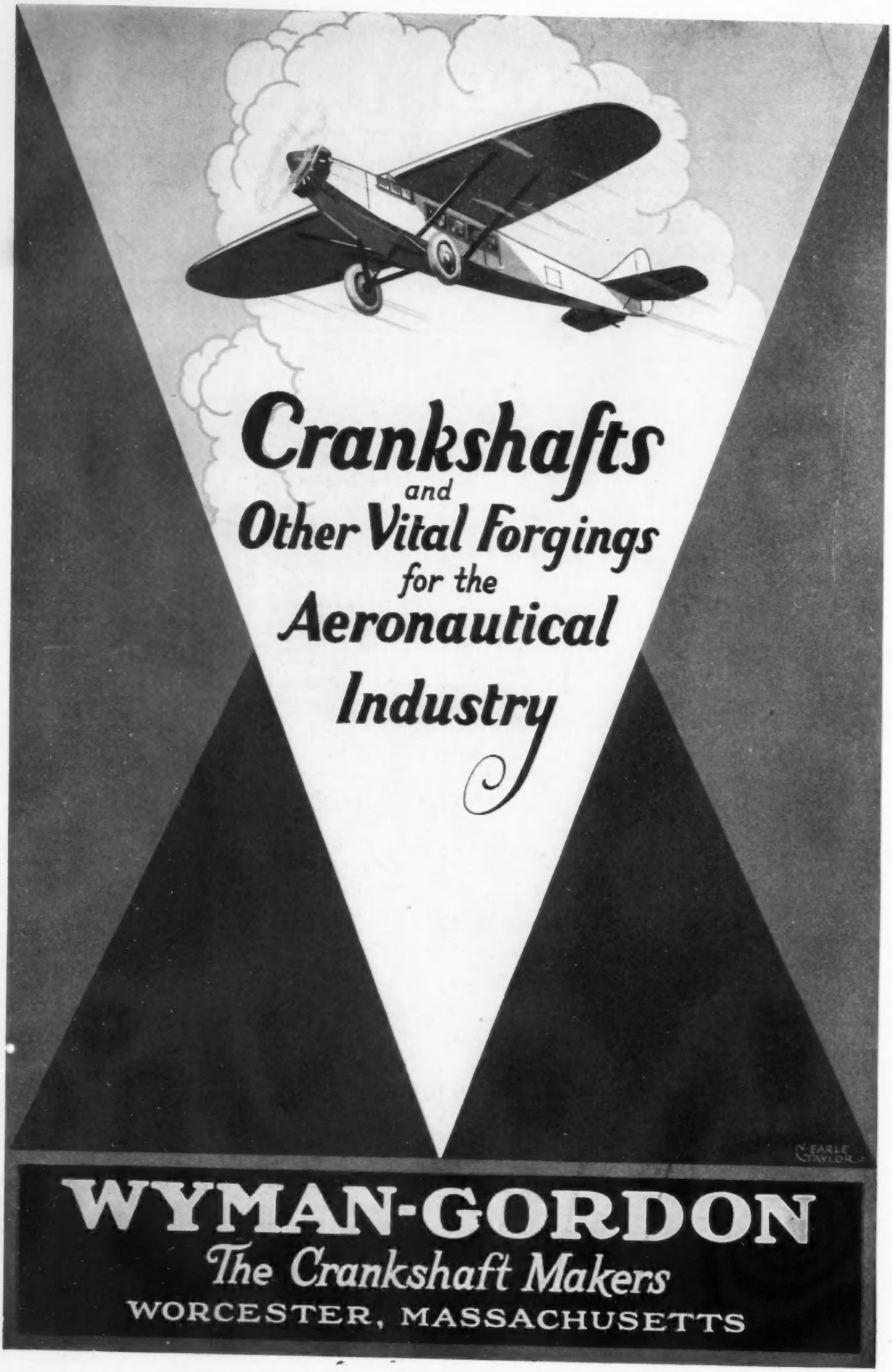
The purpose of meetings of the Society is largely to provide a forum for the presentation of straightforward and frank discussion. Discussion of this kind is encouraged. However, owing to the nature of the Society as an organization, it cannot be responsible for statements or opinions advanced in papers or in discussions at its meetings. The Constitution of the Society has long contained a provision to this effect.


Crankshafts
and
Other Vital Forgings
for the
Aeronautical
Industry
C. EARLE TAYLOR
WYMAN-GORDON
The Crankshaft Makers
WORCESTER, MASSACHUSETTS

S. A. E. JOURNAL

Vol. XXVI March, 1930 No. 3

Aircraft Progress Outlined at St. Louis

February Aeronautic Meeting Features All Phases—Wright Brothers Medal Presented to Ralph Upson at Banquet—Valuable Papers by Authorities

AIRCRAFT engines, fuels, instruments, radio equipment and production methods were featured at the Aeronautic-Engineering Meeting of the Society held at the Hotel Jefferson, St. Louis, Feb. 18 to 20, inclusive. The widening scope of the aircraft industry was indicated in numerous ways by the points brought out and emphasized in the various papers presented and in the informative discussions which followed their presentation. The authors included representatives of prominent aircraft companies, the Bureau of Standards, the Bureau of Aeronautics, the Guggenheim Fund for the Promotion of Aeronautics, the Department of Commerce and of research laboratories.

More than 300 members and guests attended the Meeting, most of whom participated in the joint banquet with the Aeronautical Chamber of Commerce, which was held in the gold room of the Hotel on the evening of Feb. 19.

With regard to aircraft engines, the interest centered on their development and operating reliability and on the relation between automobile-engine and aircraft-engine design. The vapor-locking tendencies of aviation gasolines and the gasoline requirements of commercial-aircraft engines were subjects treated authoritatively by representatives of the Bureau of Standards. Aircraft flight-test instruments were illustrated and described, and details were given of how an airplane can be flown with certainty through fog to a safe landing.

The papers on radio equipment for aircraft included the latest thought on the suppression of ignition interference, on radio communication and transport work, and on the provision of radio facilities for aircraft communication. Factors peculiar to the manufacture of aircraft-engine parts were discussed in a paper read at the production session, and production methods for airplanes were described in a second paper.

The sessions of the meeting in general were closely associated with sessions of the Aeronautical Chamber of Commerce, and the International Aircraft Exposition, which was in progress, afforded an unusual opportunity for those in attendance at the meeting to inspect all the latest types of airplane and airplane accessories.

Another feature of extreme interest was the presentation of the Wright Brothers Medal to Ralph H. Upson, this honor being conferred on him for having written the best paper presented in 1929, in the opinion of the Judges of Award of the Society. This paper, entitled Wings—A Coordinated System of Basic Design, was published in the January, 1930, issue of the S.A.E. JOURNAL. The medal was presented to Mr. Upson, with appropriate ceremony, at the Aircraft Banquet.

Acknowledgment of Cooperation

The Society desires to express its appreciation and thanks to all those who contributed toward making this Aeronautic Meeting decidedly successful. Among these are the authors of the various papers, the members and guests who contributed discussion, the chairmen who conducted the sessions; Charles Lawrance, toastmaster at the Aircraft Banquet; the Aeronautical Chamber of Commerce of America, Inc.; and Cliff W. Henderson, manager of the International Aircraft Exposition.

As stated in the following reports of each session, the chairmen were B. G. Leighton, engines; T. A. Peck, fuels; Charles H. Colvin, instruments; Paul Goldsborough, radio; and President Edward P. Warner, production. Their stimulating and constructive remarks on the subjects at issue were effective in securing from the at-

RALPH H. UPSON RECEIVING AWARD OF WRIGHT BROTHERS MEDAL

Presented by Dr. George W. Lewis, of the Board of Awards, on Behalf of the Society of Automotive Engineers for the Best Paper Presented before the Society in 1929 on Aerodynamics, Structural Theory, Research or Airplane Design or Construction. Reproduction from Movietone Film Taken at the Dinner

Meetings Calendar

National Meetings of the Society

Detroit Aeronautic—April 8 to 10

Book-Cadillac Hotel

Metropolitan Aeronautic—May 7

New York City

Summer Meeting—May 25 to 29

French Lick Springs

Chicago Aeronautic—August

(In conjunction with National Air Races)

Transportation—Early October

Production—Late October

Book-Cadillac Hotel, Detroit

March Section Meetings

Buffalo Section—March 11

Hotel Statler; 8 p.m.

Production—L. F. Maurer, Pierce-Arrow Motor Car Co.

Canadian Section—March 19

Royal York Hotel; Dinner Meeting

Speaker—Mr. Baker, Chief Engineer, Willys-Overland Co.

Cleveland Section—March 10

Hotel Cleveland

Engine Lubrication Systems and the Influence of Various Designs on Oil Contamination and Circulation—R. C. Darnell, Chief Engineer, Taylor Bros. Mfg. Corp.

Dayton Section—March 12

Dayton Engineers Club

Automotive Radio—L. M. Perkins, Radio Engineer, General Motors Radio Corp.

Detroit Section Aeronautic Division—March 3

Book-Cadillac; Dinner at 6:30 p.m.

Air Transportation—Paul Henderson, Transcontinental Air Transport

Detroit Section Body Division—March 24

Book-Cadillac; Dinner; Technical Session at 5:30 p.m.

Squeaks and Rattles—Ralph Bills.

Indiana Section—March 13

Subject—Automobile Lighting

Metropolitan Section—March 20

Packard Service-Station Building, 54th Street and 11th Avenue

What a Modern Service-Station Means—Col. J. W. Florida

Milwaukee Section—March 5

Milwaukee Athletic Club; Dinner, 6:30; Meeting, 8:00 p.m.

Application of Automotive-Type Engines to Industrial Service—J. B. Fisher, Chief Engineer, and L. L. Bowers, Field Engineer, Waukesha Motor Co.

Northwest Section—March 7

Gowman Hotel, Seattle

Aluminum-Alloy Pistons—Thomas D. McLaughlin, Ray Day Piston Co.

Oregon Section—March 14

Multnomah Hotel, Portland; Dinner, 6:30 p.m.

Why Automotive Engineers Design New Models—William Ross Knudsen, Parts and Service Manager, Chevrolet Motor Co.

Pennsylvania Section—March 12

Philadelphia Automobile Trade Association Building; Dinner, 6:30 p.m.

How to Design for an Easy Ride—John Warren Watson

Pittsburgh Section—March 20

Gasoline—T. A. Boyd

Southern California Section Aeronautic Division—March 14

Airships; Past, Present and Future—V. R. Jacobs, Goodyear Tire & Rubber Co.

tending members discussions of points that otherwise might not have been covered, as well as in themselves furnishing distinct contributions to the development of a thorough consideration of all the phases involved. In this manner they exemplified the desirable procedure recommended by President Edward P. Warner in his address at the Aircraft Banquet; that is, after having secured an interested audience of members and guests who certify to their interest by the very fact of their presence, the chairmen were successful in increasing the percentage of discussions presented from the floor.

Gala Aircraft Dinner Given

Notable Personages Assemble at Joint Banquet with Aeronautical Chamber of Commerce

AN UNUSUAL feature of the Aircraft Dinner held Tuesday evening, Feb. 19, was the individual introduction of each guest of honor by Toastmaster Charles Lawrance, vice-president of the Curtiss-Wright Corp. His introductions were most happily phrased and in each instance were inclusive of references to each guest's personality and achievements. Nearly 300 members and guests attended, and hilarious applause greeted the humorous remarks by Chairman Lawrance and the stories told in dialect by William B. Stout.

The members and guests of honor who were seated at the speakers' table were as follows:

T. A. Peck, Shell Petroleum Corp.

Major A. B. Lambert, owner, Lambert Flying Field; member, St. Louis Municipal Airport Committee.

Fred M. Worthy, Axelson Aircraft Engine Co.

Walter Schmidt-Rex, Lufthansa, Germany.

Col. B. F. Castle, Great Lakes Aircraft Corp.

President Edward P. Warner, editor of *Aviation*.

Col. Halsey Dunwoody, Universal Aviation Corp.

Ralph H. Upson, aeronautical engineer, Red Bank, N. J.

Dr. George W. Lewis, National Advisory Committee for Aeronautics.

Charles L. Lawrance, Toastmaster; Curtiss-Wright Corp.

K. M. Lane, United States Department of Commerce.

Herbert Hoover, Jr., Western Air Express.

G. C. Gross, Federal Radio Commission.

William B. Stout, Stout Air Services, Inc.

SOME OF THE NOTABLES WHO TOOK PART IN THE DINNER SESSION AND WERE SEATED AT THE SPEAKERS TABLE

(Upper Row) K. M. Lane, of the Department of Commerce, Who Made an Address on the Defects of Modern Aircraft; Ralph H. Upson, Winner of the Wright Brothers Medal for 1929; Clarence L. Lawrance, of the Curtiss-Wright Corp., Toastmaster; William B. Stout, of the Stout Air Services, Who Told Dialect Stories

(Lower Row) Clarence M. Young, of the Department of Commerce; Clifford W. Henderson, of the National Air Transport; Col. B. F. Castle, of the Great Lakes Aircraft Corp.; and Walter Schmidt-Rex, of the Lufthansa, Germany, Guests at the Dinner of the Society and Aeronautical Chamber of Commerce

Major R. H. Fleet, Consolidated Aircraft Co.
Clarence M. Young, United States Department of Commerce.
James H. Doolittle, Shell Petroleum Corp.
Clifford W. Henderson, National Air Transport.
Bruce G. Leighton, Wright Aeronautical Corp.
Clyde Cessna, Cessna Aircraft Co.

A second feature of the evening was the presentation of the Wright Brothers Medal to Ralph H. Upson, the presentation being made by Dr. G. W. Lewis, of the National Advisory Committee for Aeronautics. The medal is awarded by the Society each year for the best paper presented before the Society during the preceding year on aerodynamic research or airplane design or construction. Quoting Dr. Lewis:

The Board of Awards had a difficult time this year in making a selection, as many excellent papers were presented. In awarding the Wright Brothers Medal, the Society selects the best paper, primarily for its value as a new contribution to existing knowledge of the aeronautic art. It is my pleasure to inform you that Ralph H. Upson has been selected to receive the Wright Brothers Medal for the year 1929.

Mr. Upson has distinguished himself in successfully creating the only metal-clad airship in the world and, in presenting his paper entitled, Wings—A Coordinated System of Basic Design, he has further distinguished himself in the science of aeronautics. Mr. Upson, on behalf of the Society of Automotive Engineers, I herewith present to you the Wright Brothers Medal for the year 1929, together with a certificate of award signed by the Board of Award.

In accepting this honor, Mr. Upson appropriately expressed his appreciation and thanks to the Society.

Development of Aviation Science

Before introducing the principal speaker, Toastmaster Lawrance talked briefly with regard to the development of the science of aviation. He said in part that for the last several years all the members of the aircraft industry have been fortunate enough to be in an intense era of production which has enabled them to manufacture successfully aircraft of very good quality that have given us a standing in the world in commercial aviation that we never had before. But as we look over the field during that period, we notice only improvements in the nature of refinement, he continued. We do not find any sensational changes in the art of construction or in the principle of aircraft and engine design. Then came a time when things were not so propitious. We were overproduced and the companies had to reduce some of their activities. That is not particularly significant or sinister, he said, but nevertheless is a situation with which we had been confronted for a time.

When production is slack is the time for research, and Mr. Lawrance said that he could not stress too highly the importance of research in a new art. The companies in this Country that have made the most headway, that are the most powerful, and that have made the greatest advance in contributions to science and to mankind are the companies that have employed experts in science and engineering.

The toastmaster argued that both the aircraft engine and the airplane can be developed to a much higher degree than they are today, and said that now is the time to institute research and develop new models without having difficulty in introducing them into the production line. He then introduced K. M. Lane, of the United States Department of Commerce.

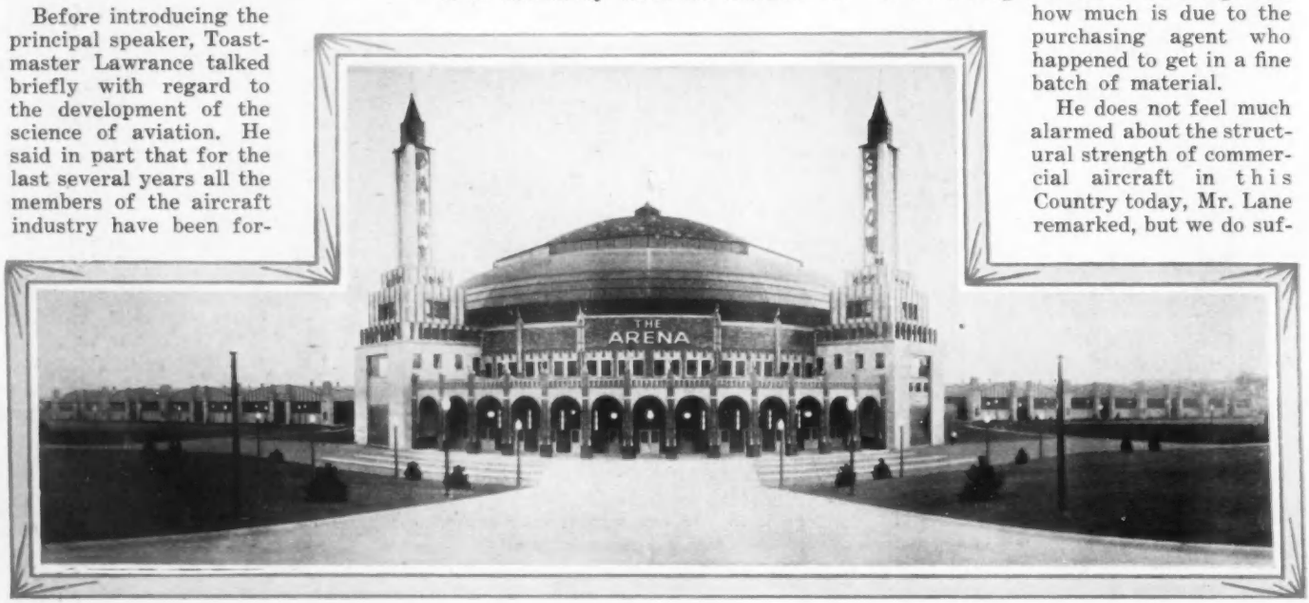
Defects of Modern Aircraft

Mr. Lane said in part that the Department of Commerce has set up certain minimum requirements and that it is absolutely essential that an airplane meet those requirements. We have emphasized structural strength possibly to the exclusion of some other features, he remarked, because we believe that structural strength is the starting point in airplane design. There are also a number of minor details that are possibly incapable of exact analysis, where the formula for calculation of strength includes the well-known plus or minus J, where J stands for judgment. Without being too specific, the speaker called the attention of designers to some of the defects that come to the attention of the Department.

There seems to be a tendency to forget the space between the real spar and the aileron false spar, Mr. Lane continued. The aileron itself is tested and the spars as calculated show good margins of safety over the requirements, but the attachment of the aileron false spar to the real spar, which enables the false spar to carry the load through and get it back to the fuselage so that it is useful in picking up the wing, seems to be ignored. It is a force that is rather difficult to calculate, and the only thing to do is to make sure that it is well tied in. The control surfaces are well taken care of. A great deal of trouble has been experienced with control surfaces and control systems due to wear at hinges and resulting slop, which causes vibration and flutter; and that is true of horizontal tail-surfaces and fixed stabilizers.

Mr. Lane said also that landing-gears still seem to be of somewhat doubtful character. In connection with the design of indeterminate structures, he stated that the Department is willing to accept static tests if the manufacturer also tests the material he uses and his specimens are subjected to the static test to determine just how much of the strength is due to his design and how much is due to the purchasing agent who happened to get in a fine batch of material.

He does not feel much alarmed about the structural strength of commercial aircraft in this Country today, Mr. Lane remarked, but we do suf-



ARENA AT ST. LOUIS IN WHICH THE INTERNATIONAL AIRCRAFT EXPOSITION WAS HELD FROM FEB. 15 TO 23

fer from maintenance problems because of insufficient wearing surface. These are things that are rather hard to prescribe, and the Department hesitates to do any such thing. It does not feel that life is involved or even damage to property in most cases, but it has insisted on sufficient wearing surface in control systems and control surfaces. Aside from that, it is a sales proposition and not one that should bother any regulatory department.

Aerodynamics Considered

In the opinion of the speaker the industry has not progressed as well in aerodynamics as it has in structures. From a study of crash reports, considerable research as to the behavior of the airplane in a stall is still needed. Many studies have been made of spin characteristics by a number of manufacturers who have had such trouble but, to date, no really definite conclusions are to be drawn from those tests. Each case has been a satisfactory correction possibly of the individual design, but we are still very much in the dark as to just what happens and what should be done to keep it from happening again on another plane with slightly different characteristics. This is one of the most serious defects, in his opinion. He proposed that the Society attempt to confer with the various pilots and engineers who have been studying spin characteristics, with a view to determining just what the underlying causes are and the most effective means of preventing them. He also remarked that great attention has been paid to longitudinal control and directional control but no one seems to be particularly interested in lateral control.

Public Appeal of Aircraft

Among the features which tend toward increasing the appeal that aircraft make to the general public are their general esthetic or social aspect, reduction of noise and increase of comfort. A great deal still remains to be done to reduce noises caused by the propeller, the plane wires and bracing, and the general reverberation of the streamline swill around the sides of the fuselage, Mr. Lane remarked. The provision of satisfactory ventilation would decrease the tendency toward airsickness, he said.

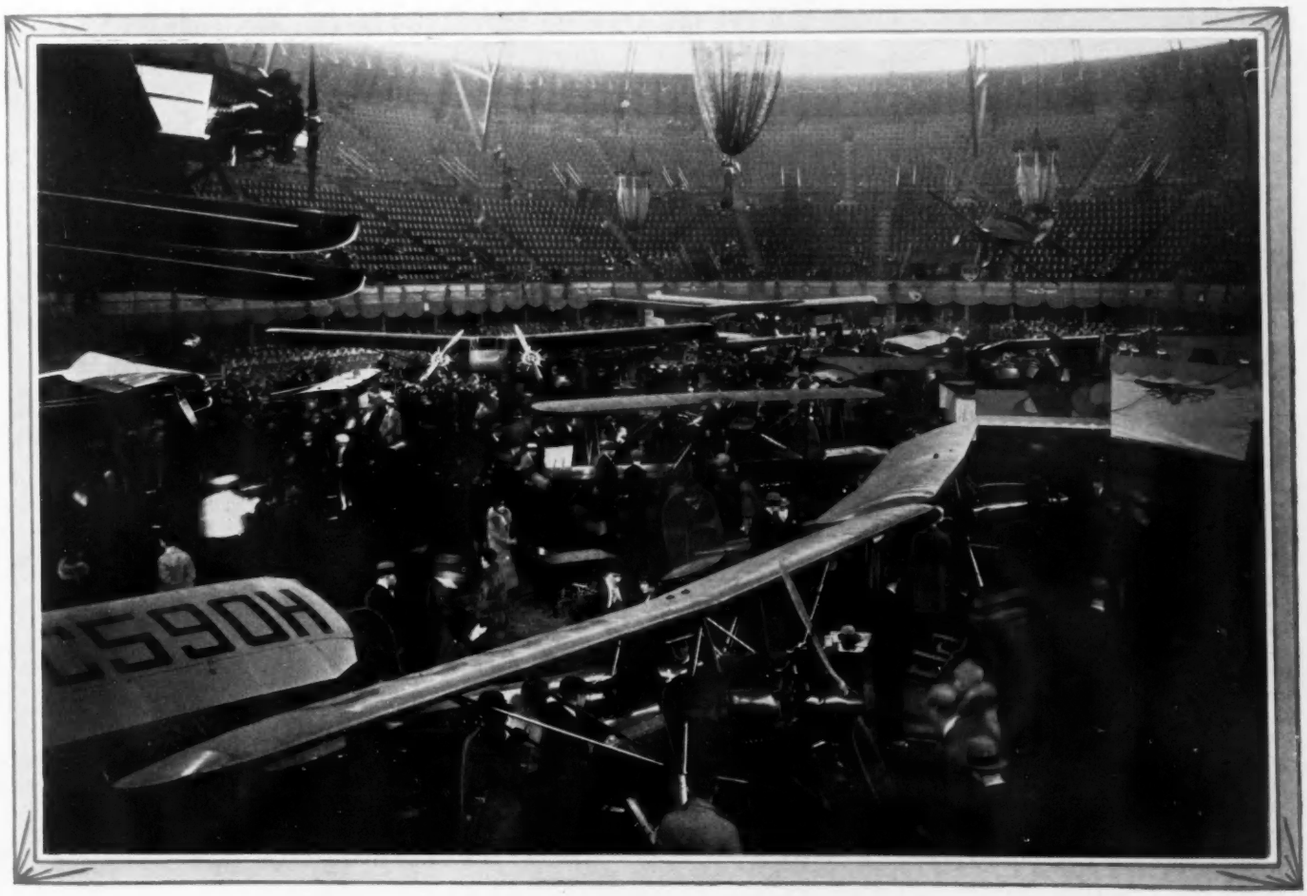
In conclusion, Mr. Lane laid emphasis upon the necessity for protecting aircraft from fire and made a plea for honesty in aircraft advertising.

Address by President Warner

President Edward P. Warner, editor of *Aviation*, remarked that the Society is interested in aeronautics only if the members are interested in aeronautics, and only insofar as they are interested. The Society's service to aeronautics is measured precisely by the interest the aeronautic engineers, production men and executives with at least a secondary technical interest, take in the work. It is impossible to promote from the New York office of the Society anything that is not willingly supported by the membership the Nation over, and it is impossible for meetings to have any value unless they, too, are genuinely supported and unless there is a considerable and a definitely interested attendance of members and visitors.

Object of Society Meetings Stated

The object of Society meetings such as this, said Mr. Warner, and the particular in which they differ from anything that is in the first place written for magazine or book publication, is the



INTERIOR OF THE ST. LOUIS ARENA DURING THE AIRCRAFT EXPOSITION

Many More Exhibits Were Displayed in Exhibition Buildings A and B, Adjoining the Arena on Either Side

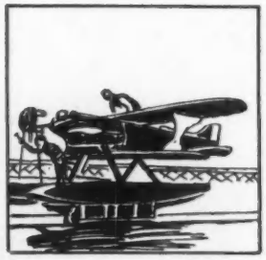
attraction of an audience of members and guests who certify to their interest by the very fact of their presence and the percentage who take some active part in discussion.

Mr. Lane's paper on the Defects of Modern Aircraft, pointed out President Warner, is typical of the sort of provocative, attention-demanding, inquisitive, technical summary of the state of an art, as seen from a particular point of view; it is of a type indicating how the S.A.E. can best serve its members by presenting such papers to them in their meetings. At the Engine Session, he said, Mr. Chilton proposed a series of questions to the airplane manufacturers of America or, it would be fair to say, of the world. Mr. Lane propounded another series of inquiries by inference, offering them specifically as suggestions.

These speakers reminded us, said President Warner, that it is impossible to standardize the progress of the aviation art or any other engineering art; it is impossible to summarize in a sentence or to say "This way lies progress," because progress lies in all directions. That was happily indicated in Mr. Lane's observations, offered within a few minutes of each other; that, on the one hand, there is no such thing as too much refinement in structural analysis, that methods which used to be disposed of as theoretical have come into a very practical application, and more and more refinement will be needed; and then, swinging to the other extreme into a region in which no calculation is possible, emphasized the importance of those minor refinements which do not belong in the sphere of calculation but demand the constant attention and care of the engineer and the constant application of his judgment to detail.

Perfection of Detail Essential

We must all have been struck forcefully, said Mr. Warner, by the extent to which a design that is admirable in its major particulars, as major particulars are commonly determined, can be destroyed for practical utility by little details such as the incorrect placing of a heater, a window that does not open, or a seat that is uncomfortable. These meetings serve to remind us of such things and afford opportunity to submit the speaker to an inquisition from which we all stand to benefit.



We have all been trying for the last several years to plot the course of the airplane industry and of aeronautic science and to project it into the future; we have all been trying to gain knowledge here and there and pile these straws up one on another until we are satisfied that we have formed a complete model of what the airplane industry and aeronautic science are and are going to be; and we have tried to decide what is a good sign and what a bad sign for the future.

Era of Secrecy Ended

No tendency has been more unfavorable than that which manifested itself eight years ago in an extreme of secrecy, the speaker continued. There is no branch of technical science the members of which have not learned in proportion as they exchanged information with one another and submitted their mistakes frankly for the criticisms and suggestions of their fellows. We are somewhat slow to acquire that attitude in the aircraft industry, according to President Warner, perhaps because we became accustomed to a feeling of secrecy and confidential knowledge during about 20 months through 1917 and 1918. He said that he still has a bulletin printed on blue paper with a large red line across the top reading, "Secret and Confidential," and which uses about five lines to convey the information that it is not a good idea to spill acid from storage-batteries onto airplane wings.

We acquired the habit of secrecy during the war and remained secret and confidential after the war, said Mr. Warner, but now we hope we are cured. We have certainly advanced a long way toward the cure, having trodden the course that other branches of technical science have followed as they came to maturity and attained a state of development which those who were proud of their connection with that work could consider as at least approaching the status of being satisfactory. The aircraft industry is on that road and he is satisfied is going to continue on it. He said he is satisfied that the Society will continue to make contributions, because the members of the Society will continue to submit papers that tell what they have done and what they have failed to do, what they have observed that others have done or perhaps failed in doing, and that other members will stand up and discuss the papers with their respective authors.

Airplane Production Methods

Manufacture of Airplanes and Aircraft-Engine Parts Analyzed Thoroughly at the Production Session

PRESIDENT Edward P. Warner, editor of *Aviation*, was Chairman of the Production Session, which convened on Thursday evening, Feb. 20. William B. Robertson, president of the Curtiss Robertson Airplane Co., presented his subject, Production Methods of Airplanes, in its various phases. In another paper, William F. Wise, of the Ex-Cell-O-Aircraft & Tool Corp., discussed the Factors Peculiar to the Manufacture of Aircraft-Engine Parts.

Production routine and technique constitute the two main phases of airplane-production methods, in Mr. Robertson's opinion. He defined the former as being the order of production in a factory organized for the building of airplanes, starting with the original conception of design; its impression upon those in position to authorize sales estimates; its release from the engineering department; the phases of its steps from the supply of raw materials through the stockroom, inspection department, and factory department; its assembly and its delivery into the hands of the sales distributing organization. He stated that production technique means the control of the critical cost-factors in building successful airplanes at a cost enough less than the manufacturers' sales price to assure the successful operation of the company.

In discussing production routine, Mr. Robertson remarked that this use of the word "production" referred to the manufacture of an airplane of which the experimental types already had been built, which had been approved by the sales department and the executives, and on which it had been agreed that production might proceed. The first step is to determine the size of the initial production-run, he said, and then went into detail as to tooling, materials, and the like, including also details of the sales department's relationship to the production department and its influence thereon.

As to production technique, Mr. Robertson considered the initial factors that affect airplane costs, listing the three main items of labor, material and overhead. Another main classification includes royalties, designers' rates, or development changes which are not carried in the ordinary production overhead. After saying that unless the overhead can be controlled within 100 per cent, the factory will

have red-ink figures at the end of the year, and considering the several factors already mentioned, the speaker divided the list price of an airplane equipped with a new production engine as follows: sales discount, 25 per cent; engine cost to manufacture, 30 per cent; material, other than engine, cost to manufacture, 20 per cent; miscellaneous royalties, development, and the like, 5 per cent; labor, 8 per cent; overhead, 7 per cent, and profit, 5 per cent.

Aircraft-Engine Parts Manufacture

Mr. Wise, in his paper, stated in part that, with regard to the requirements of the aircraft industry for highly developed materials that are properly machined and heat-treated, the highest requirements of the automobile industry have proved to be merely a preparatory school for the successful manufacture of aircraft-engine parts. He remarked that the permissible weight of an aircraft engine ranges from one-half to one-third that allowable for an automobile engine, which operates at approximately 20 per cent of its full power-output 80 per cent of the time, under conditions which make it virtually impossible for maximum power-output to be required for more than 5 to 10 min. consecutively. But the aircraft engine, he said, except during the warming-up period on the ground, rarely delivers less than 75 per cent of its maximum power-output, and an engine design which is not capable of 50 continuous hours of service at maximum power-output is not considered worthy of the approval of the Department of Commerce.

WILLIAM F. WISE

Of the Ex-Cell-O Aircraft & Tool Co., Who Presented a Paper at the Production Session on Factors Peculiar to the Manufacture of Aircraft-Engine Parts

Mr. Wise enumerated some of the more important factors having to do with the prevention of expensive and disastrous engine failures as being the selection of the proper material for a given part; the correctness with which the material meets the specified analysis; its freedom from mechanical defects such as roll seams, pipes, slag inclusions and forging defects; heat-treatment; machining, grinding and production operations; and inspection. He then entered rather deeply into the subject of inspection and the other factors mentioned, and concluded by saying that equipment, experience, skill, and above all a conscientiousness of long and cherished record are the wings upon which the various branches of the industry must mount, be they that of the plane manufacturer, engine builder, or engine-parts specialist.

Production Needs Early Recognition

The discussion following the papers included remarks by Chairman Warner, who said in part that it is always the fate of the production man to be unappreciated in the first stages of an industry's development. Continuing, he remarked that the production man always lets the scientist get a head start and assume a leading rôle, and that it is a matter of several years before it comes to be generally realized that the transition from blueprints into a form fit for the use of the ultimate consumer is not an automatic one. It takes time to realize that production is fully as specialized and highly developed an art as is design, and that it has just as distinctive a rôle and has commanded as much faithful study and the burning of as much midnight electricity as has the planning or the fundamental research.

This was the first Production Session that the Aeronautic Activity of the Society has held, Chairman Warner pointed out, and as such, it marked an epoch. It also constituted the formal recognition of production as a branch of aeronautic engineering; at least, he said, it was an open salutation by the Society to the production branch of the industry and to the production engineer who applies himself to aeronautic problems.

EDWARD P. WARNER

President of the Society and Chairman of the Production Session

In reply to a question, Mr. Wise said that his company believes that the inspection department should report to the general manager so that the engineering department or the factory can control the type of work that is being done. He stated also that the ratio of inspection cost to direct-labor cost is approximately 2.5:1 as compared with the automobile cost. In other words, the cost for aircraft is about twice that for the automobile.

To another question, Mr. Wise answered that rejections are charged to the production department, on the basis that, since this department produced the part, it should be charged with that part. He stated further that his company does not own a laboratory but has its work done by an outside testing-laboratory so that all data rendered by the laboratory will be entirely unbiased.

Instrument Perfection Sought

Available Aviation Aids Described and Their Application to Fog-Flying Discussed at Third Session

THE OBJECT of the first paper presented at the Instrument Session on Wednesday morning, Feb. 19, was to discuss certain instruments and methods which are at present used by the Flight Test Section of the Navy Department. It was prepared by J. B. Peterson, of the Bureau of Standards, and E. W. Rounds, of the Bureau of Aeronautics, Navy Department, and is printed in full in this issue of THE JOURNAL, beginning on page 313. The Bureau of Standards has for a number of years cooperated with the Flight Test Section in the development, testing and calibration of flight-test in-

struments, and much valuable information can be gleaned by a careful reading of the paper.

Charles H. Colvin, president of the Pioneer Instrument Co., of Brooklyn, N. Y., was chairman. This, as well as the Engine Session on Tuesday morning, was convened as a stated business session of the Aircraft Activity to name its Activity Nominating Committee to designate the nominee for Vice-President of the Activity for 1931. In each instance, the nominations were made as stated on p. 389 of this issue.

Commerce Department's Air-Speed Requirements

Discussion of the Peterson and Rounds paper brought out that the Department of Commerce has stated that its intent, in connection with its requirements for recording air-speeds, is to be sure that the air speed does not change during the test rather than to have an accurate measurement of air speed, and this imposes a much lower requirement on the instrument, according to Chairman Colvin. He also said that the recording air-speed indicator is an inherently difficult instrument because it is a differential pressure-gage. In an indicating air-speed indicator that matter is quite simple because the entire mechanism can be enclosed in an air-tight case and one pressure will be within the case and one within the diaphragm. Since the recorder is an instrument of considerable sensitivity and because it must be accessible for changing parts, the problem of making it act largely as a differential gage is greatly increased.

Flying an Airplane in Fog

Experiments conducted by the Daniel Guggenheim Fund for the Promotion of Aeronautics to determine the feasibility of flying an airplane guided by instruments alone were described by Lieut. James H. Doolittle, U.S.A., in his paper on Flying an Airplane in Fog. The paper begins on page 318 of this issue.

Some of the points brought out in the discussion were related to the location of the marker beacon. E. M. Kinney, of the General Electric Co., asked whether it should be buried in the center of the field to mark the point at which the wheels should be in contact with the ground, or, if at that point the instrument indications show that the wheels are not in contact, the pilot should speed up the plane and circle around again. Lieutenant Doolittle said that his idea of the eventual set-up would be to have the main landing-beacon located in the center of the field because, when he passes over it, the pilot gets a very distinct indication. At that point the reeds begin to vibrate in an opposite direction and, between the time they vibrate one way and then in the other, they stop.

Asked by A. W. Parks, Jr., of the Radio Frequency Laboratories, what sort of signals indicate the edge of the landing-field, Lieutenant Doolittle replied that these are given by a single vibrating-reed, operating at 40 cycles. As the pilot approaches the field, the amplitude of vibration of this reed increases; then, when he passes the edge of the field, it stops and, on the other side, begins to vibrate again. It operates up to 80 deg. of bank. Above 80 deg. of bank the instrument becomes inoperative and a few minutes elapse before it settles down, resumes its proper position and starts again.

Engine Development and Reliability

Airplane Engines Considered as to Design and Operation at the Engine Session

IN THE development of any new industry the types which become standardized follow the styles with which the initial financial successes were made, rather than technical considerations as to the merits of the various designs available, said Roland Chilton, of the Wright Aeronautical Corp., in his paper on Airplane-Engine Development and Operating Reliability presented at the Engine Session held Tuesday morning, Feb. 18, in the crystal room of the Hotel Jefferson at St. Louis. So long as airplanes land at about railroad-time speed and traverse the average scenery, he continued, reliability must be the prime consideration in designing their powerplants, at least as regards failures involving forced landings. B. G. Leighton, of the same corporation, was chairman, and nearly 100 members and guests were in attendance at the session.

The second paper was on the subject of the Relation Between Automobile and Aircraft-Engine Design and was presented by Robert Insley, vice-president of the Continental Aircraft Engine Co. The author dwelt upon the commercial rather than the purely engineering aspect of this subject. He said that five general characteristics—speed, economy, safety, comfort and convenience—determine the popularity of any form of transportation. Further, he said that, just as in speed alone the automobile surpassed the horse and buggy, and on this basis was sold to the eager public in rapidly increasing numbers, so the airplane today finds itself in much the same position with respect to the automobile. Its chief asset is speed. In first cost and in maintenance, it is much more expensive, and its safety is openly questioned; but, in Mr. Insley's opinion, since the automobile industry worked out its problems and one by one converted its liabilities into assets, aircraft engineers can do likewise with regard to the cost, safety, comfort and convenience of the airplane.

CHAIRMAN AND SPEAKERS AT THE INSTRUMENTS SESSION

Charles H. Colvin (Left), of the Pioneer Instrument Co., Chairman; J. B. Peterson (Center), of the Bureau of Standards, Who Delivered a Paper on Flight Test Instruments; Lieut. James H. Doolittle (Right), of the Shell Petroleum Corp., Formerly of the Army Air Corps, Who Told of His Fog-Flying Tests by Instruments for the Daniel Guggenheim Fund for the Promotion of Aeronautics

Airplane-Engine Development

In the course of his paper, Mr. Chilton said in part that the required high order of reliability cannot be achieved

by the mere elimination of such defects as are developed by dynamometer endurance tests of a few sample engines. A few types of aircraft engine may have reached the "experience figure," but every popular automobile model has exceeded it many hundreds of times.

In one sense, Mr. Chilton remarked, the situation develops in a circle; improvements in reliability grow out of an increased use, while any large increase in aircraft use probably awaits the demonstration of improved reliability. He based this comment on his conviction that safety is the factor in which air travel is popularly regarded as doubtful and that, until the landing characteristics of airplanes are changed drastically, engine failures on transport machines are incompatible with public confidence. He said further that when the airplane comes to be generally regarded by those outside of the industry as comparable in safety with the automobile, the greater cost of air travel will not prevent its reasonably rapid expansion as to usage. He stated also that the recent optimism as to the rate of increase in aircraft use will not be fulfilled unless these developments result in increased reliability.

Engine and Plane Are Interdependent Units

From the viewpoint of utility, the engine designer cannot achieve an efficient product unless informed on the many airplane requirements after considering the engine and the airplane as interdependent units. Mr. Chilton said that his remarks were intended to spur the airplane experts to criticize the shortcomings of existing powerplants as regards the efficiency of the completed craft. He stated that the desire of his company is to know "what the plane designer is up against when he sets out to hang our product onto his; things which indicate in a general way where we stop and where he begins."

Weight and drag for a given horsepower are prime factors that determine airplane performance, according to Mr. Chilton, and the latest engine and cooling installations probably constitute less of the total parasite resistance of the plane than does the average landing-gear. Ultimately, both will be disposable inside the streamline envelope of the craft. The speaker then went into some detail regarding performance, including considerations of reduced drag due to special cowling, head resistance and improvements in power-weight ratio. Supercharging was said to be one of the most successful expedients for securing improvement in the power-weight ratio and reasons for this were given.

Fatigue Limit of Materials Discussed

Relatively little difficulty is now experienced in developing the design of each part so that the operating stress-range is safely within the fatigue limit of homogeneous material, and Mr. Chilton also remarked that the "quality" of modern alloy steels is excellent in normal specimens but the weight reduction that this should allow will not be realized successfully until this quality can be guaranteed by inspection to extend through every element of every piece. He also discussed the subjects of wear, thermal conditions and failures of such parts as crankshafts, valve-springs, pipe lines and supercharger drives. In conclusion he made various comments on the solid-injection type of compression-ignition engine.

Valves and Other Features Discussed

Before opening the meeting for discussion, Chairman Leighton made comments to the effect that the aircraft industry is new and its production capacity is about five times larger than the market. One of the best ways to create a market is to reduce costs, he said, which necessitates finding out what is going on and how to eliminate waste effort and additional costs of development. As he sees the purpose of the Council of the Society in establishing the Aircraft-Engine Activity as a separate Activity, it is to gather together those who are interested in development and afford them an opportunity to exchange ideas.

In reply to a question by E. B. Heath, of the Heath Aircraft Corp., concerning the diameter and weight of valve-stems, Mr. Chilton said that the heat can be dissipated from the head by conducting it to the valve-seat, which is relatively cool, and by conducting it up the stem to the guide, if the guide is relatively cool. He remarked that the virtue of large-diameter valve-stems is that the temperature along the stem is reduced by the large section. The disadvantage is that the valve is heavy. The compromise he suggested is to use a salt which melts, splashes up and down the stem and transmits the heat from the bottom of the valve to the top and also to the valve-stem guide if it is well cooled.

The effect of change in valve clearance on valve timing was brought out by J. H. Geisse, of the Comet Engine Corp., who also discussed the design of the exhaust ring on mufflers.

P. B. Taylor, of the Wright Aeronautical Corp., said that it is possible, with a given fuel, to increase the power output of the engine if a sacrifice is made in fuel consumption, but that is the reason it is so important for the airplane manufacturers to specify what they want. He stated that both the additional power and the low fuel-consumption are becoming more and more feasible on account of the better grades of gasoline available, and that, within certain limits, the two can be proportioned in any desired ratio.

CHAIRMAN AND SPEAKERS AT THE ENGINE SESSION

B. G. Leighton (Left), of the Wright Aeronautical Corp., Chairman; Roland Chilton (Center), of the Wright Aeronautical Corp., Who Gave a Paper on Airplane-Engine Development and Reliability; Robert Insley (Right), of the Continental Aircraft Co., Who Presented His Paper on Relation between Automobile and Aircraft-Engine Design

Future Trends Specified

Dr. G. W. Lewis, of the National Advisory Committee for Aeronautics, said that the time has come when, in his opinion, the manufacturers should furnish the cowling with the radial air-cooled aircraft-engine. He mentioned that the Committee is making a report covering the test of cowlings, from a ring cowling 6 in. wide up to the full cowling. Despite the excellent products that are now being made, he said, the aircraft engine still contributes about 15 per cent of the causes of accidents to airplanes. He thinks that the

majority of failures are still due to the plumbing instead of to parts. In his belief, the supercharger will be developed during the coming year, especially for the smaller types of engine; it will not be used at all times, but will be used in taking off and when maximum power is required. He mentioned that the outlook, from the engine builder's viewpoint, seems to indicate engines that will develop maximum power with minimum resistance. He believes also that another type of engine will be built for the private operator. It will be of relatively light weight and small horsepower.

Automobile versus Aircraft Engines

Aviation has been transformed suddenly from being a sideshow to becoming a commercial enterprise, Mr. Insley remarked in his address. He said in part that automobile and aircraft engines are largely identical in general construction and operating characteristics, but serve fields of usefulness differing by several inherent characteristics and they cater to markets of vastly different proportions. These two conditions are responsible for the dissimilarity between the two types of engine and must be kept in mind when making comparisons between them.

Cost is the most disturbing difference between them, the speaker said, and he discussed this subject in some detail, saying also that weight, reliability, quantity and cost are the balancing factors in aircraft-engine production. Further, he declared that it is unreasonable to expect great improvement in any of these factors without some compensating sacrifice in the others. He said also that the factor of safety is probably even more important in aircraft-engine design in its relation to salability than is the cost factor. He commented also on the design of aircraft to secure comfort and the elimination of noise, vibration, smoke and oil odors.

Summarizing his subject, Mr. Insley pointed out that, in general, speed, cost, safety, comfort and convenience are important factors in determining the popularity of any means of transportation. The experience of the automobile industry in solving these problems may be of use to the manufacturers of aircraft engines. The chief asset of the present-day airplane is speed; the other four factors constitute problems to be solved. Cost of the airplane engine is a problem of weight, reliability and quantity produced.

Assuming that there can be no concessions in reliability, any attempt to substantially reduce cost must take into consideration either increase of weight or multiplication of quantity produced. The quantity depends upon the market and so, for the purpose of his paper, is beyond control. We are left, therefore, the speaker said, with the two-horned dilemma of high weight or high cost. The safety problem to a large extent is one of mechanical reliability but involves one other very serious task; that is, the elimination of fire hazard.

The improvement of the comfort factors in air transportation suggests many opportunities to benefit by the experience of the automobile-engine designer in reduction of exhaust and mechanical noise and improvement of vibration characteristics. Similarly, in the matter of convenience, the aircraft-engine designer approaches a problem which is old in the automobile industry and faces the necessity of living up to automobile precedent in this regard or establishing new convenience standards.

Noise, Cost Reduction and Materials

In discussing Mr. Insley's paper, Arthur Nutt, of the Curtiss-Wright Aeronautical Corp., said that a surprising number of noises will still exist in cabin monoplanes after engine noises have been eliminated. These will be caused by vibration of the cabin walls, window rattling, whistling due to the drag of struts, interference of struts and wires, and the like. Exhaust noise and propeller noise now cover up these other noises.

As to the expected decrease in cost with increased production, mentioned by Mr. Insley, it was remarked by Mr. Geisse that the question of weight probably is more important than is that of production. G. C. Brown, of the Bohn Aluminum & Brass Corp., said that the high cost of aircraft engines probably results largely from the specifications and requirements that are set up around the materials to be used in constructing them.

E. D. Herrick, of the Lycoming Mfg. Co., agreed with Mr. Insley that the cost of the materials themselves eventually will be greatly reduced through volume production. He mentioned as one reason for the high cost of materials the small-lot orders that must be specially run through the mill.

In Mr. Taylor's belief, the aircraft industry is suffering from military influence on engine construction. For example, with regard to materials, the industry has been accustomed to building with materials specified, without regard to the cost of those materials. G. D. Welty, of the Aluminum Co. of America, remarked that, as the industry has gained more and more in experience, it has found that many of the early failures were not due, fundamentally, to faulty materials but rather to misunderstood stress calculations and poor design.

Aircraft-Radio Application

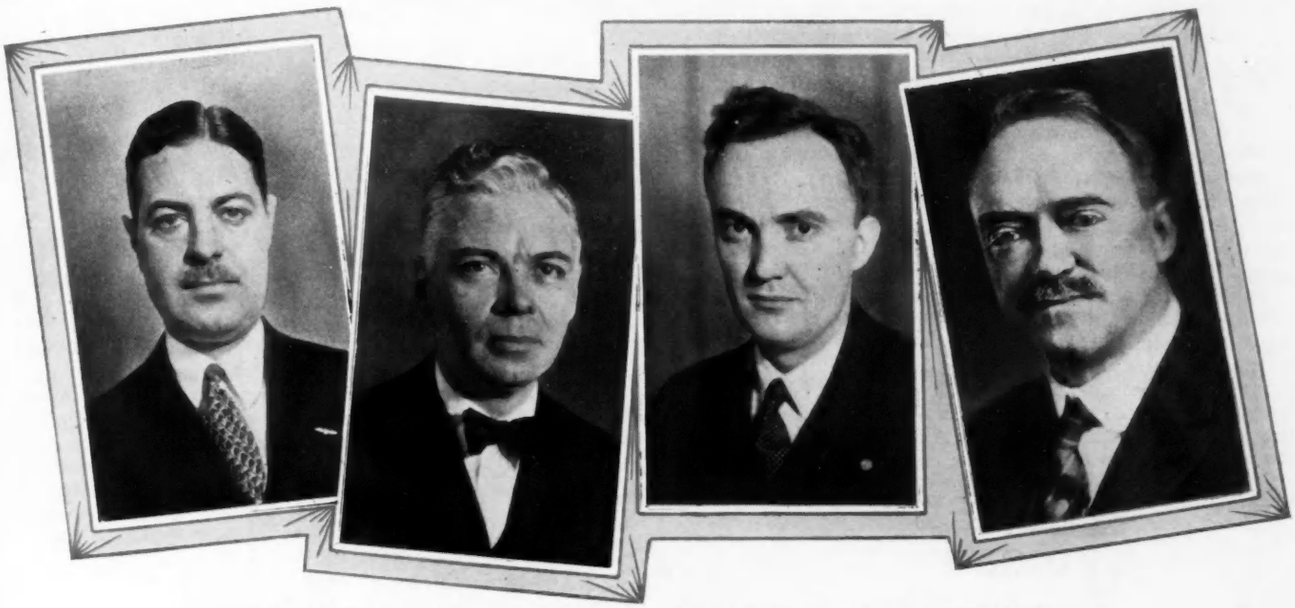
Ignition-Interference Suppression, Facilities and Communication Analyzed at Radio Session

PAUL GOLDSBOROUGH, vice-president in charge of operation for the Universal Aviation Corp., was Chairman of the Radio Session which convened Thursday morning, Feb. 20. Three papers were presented, the first entitled, The Suppression of Ignition Interference on Radio-Equipped Aircraft, by Dr. L. N. Hull, of the Radio Frequency Laboratories, and E. A. Robertson, consulting engineer of Detroit, being read by Mr. Robertson. Radio in Air-Transport Operation was the subject presented by Herbert Hoover, Jr., of the Western Air Express, whose paper is printed in this issue beginning on p. 321. The paper on the Provision of Radio Facilities for Aircraft Communication, prepared by E. L. Nelson and F. M. Ryan, of the Bell Telephone Laboratories, and read by Mr. Ryan, is printed in this issue beginning on p. 326.

HERBERT HOOVER, JR.
Delivering His Paper on Radio in Air-Transport Operation

Ingition-Interference Suppression

Mr. Robertson said in part that although it has been recognized for many years that electrical ignition systems on airplane powerplants are a prolific source of disturbances tending to prevent the successful reception of radio signals, the serious and intensive development of methods of suppressing such interference is a comparatively recent undertaking. This arises from the fact that only in recent years has special significance been attached to radio operations with limited collecting structures or antennas, over such dis-



PRINCIPAL PARTICIPANTS IN THE RADIO SESSION OF THE AERONAUTIC MEETING

(Left to Right) Paul Goldsborough, Universal Aviation Corp., Chairman of the Session; E. A. Robertson, Consulting Engineer, of Detroit, Who Presented the Paper by Dr. L. N. Hull and Himself on the Suppression of Ignition Interference on Aircraft; F. M. Ryan, of the Bell Telephone Laboratories, Who Presented the Paper by E. L. Nelson and Himself on Radio Facilities for Aircraft Communication; and C. Francis Jenkins, of the Jenkins Laboratory, a Discusser

tances that the signalling waves intercepted by these antennas are relatively weak. The rise of interest in suppression of ignition interference can best be rationalized, he remarked, by a hasty survey of the use of radio in airplanes in which ignition interference is present. He then outlined these systems.

Modern restrictions upon the receiving systems on both commercial and military airplanes have established a set of conditions which focus the designers' attention upon the complete suppression of electrical radiations from the ignition system, said Mr. Robertson, and these restrictions are both physical and electrical.

Physically they include the elimination of the trailing wire and the use of fixed vertical or horizontal antennas positioned without regard to their proximity to the powerplant. Electrically they include (*a*) operation from directive transmitters, that is, radio beacons, which at their present stage of development radiate less efficiently than standard open-antenna transmitters for a given expenditure of power; (*b*) operation from conventional nondirective transmitters over distance ranges which are comparable with the ranges of reception obtainable in "quiet" locations on the ground; (*c*) reception of telephone signals of high intelligibility in the airplane; and (*d*) use of high transmission-frequencies, that is, short waves, located in a portion of the frequency spectrum where the average airplane ignition-system is a particularly efficient radiator of disturbances.

The methods of interference suppression in vogue today are the results of wholly empirical and, in many cases, unscientific development, asserted Mr. Robertson, who said that no pretense was made in the paper at an exact analysis of the problem or a complete and logical solution thereof.

Suppressing Interference by Shielding

After discussing the nature of the interference, Mr. Robertson discoursed on the suppression of ignition interference by means of shielding. As a rule, he said, any metal fitting, cowling, or housing that interposes a physical screen between a current-carrying lead in the ignition system and the radio antenna or receiver circuits tends to reduce the interference. A completely cowled water-cooled engine may emit so little electrical disturbance that radio reception over long distances is possible without special shielding. A partly cowled air-cooled engine may offer so little interference that the proper economic balance between thorough shielding and the provision of strong and therefore expensive radio signals is a real problem. Hence, it is now common practice to shield just enough of the various elements of the ignition system to allow tolerable radio service for individual sets of operating requirements, on the theory that if the safety factor of a completely shielded ignition system is unknown, the safety factor of a half-shielded system is half known.

A constructive tendency in recent shielding development, said Mr. Robertson, is the extension of the idea that a shielding system which holds together under service conditions, if intelligently designed, may be just as successful in keeping water, oil, and dirt out of the ignition as it is in keeping noise out of the radio. The remainder of the paper was devoted to a discussion and illustrations of various shielding systems now in commercial or experimental use, which are designed for *complete* housing of all important current-carrying circuits on the airplane engine. It is believed, he remarked, that the use of partly shielded systems is only a transient phase of the whole development.

Adequate Shielding Must Evolve

In the discussion, Herbert Hoover, Jr., of the Western Air Express, stated his belief that no shielding at present has fully met the day-in-and-day-out grind of transport operations, and that it probably will develop for some time yet and will be evolved slowly. Engines were evolved gradually, he said, and he thinks that shielding experience will be very similar, particularly in regard to spark-plugs and the difficulties of standardizing connections between spark-plugs and harnesses so that many different types will be interchangeable.

C. Francis Jenkins, of the City of Washington, described tests of radio equipment made in a four-place cabin plane, having a J-5 nine-cylinder engine that was not shielded. F. M. Ryan expressed doubt whether a worthwhile distinction will be made between the necessary shielding for long-wave and short-wave reception in the plane.

The rest of the discussion was largely concerned with details regarding the merits of vertical versus horizontal antennas, sensitivity of receiving sets,

the best types of mast and their manner of mounting, and the like.

Radio's Part in Air Transport Outlined

Mr. Hoover stated in his paper that radio is rapidly becoming as vital to the pilots and operators of transport airplanes as it has been for many years to the captains and owners of ships at sea. In fact, the fullest use of radio for communication and navigation purposes is so essential to the continued success of air transportation, not only from the standpoint of general operations but as a matter of public policy as well, that it probably will be only a matter of months before there will be governmental requirements for the use of reliable radio, just as there now are now for ocean-going vessels.

In the discussion following its presentation, F. G. Gardiner, of the Breeze Corp., remarked that one of the difficulties that faces the manufacturers of shielding is that there seems to be no uniformity regarding terminals. His company manufactures about 14 different types of terminal and adapter for shielding spark-plugs. He therefore recommended that standardization of terminals be put before the Standards Committee to secure uniformity.

At the conclusion of the discussion, Gerald C. Gross, of the Federal Radio Commission, compared American and European aviation radio-equipment. He based his remarks on a survey he made in Europe following the conclusion of the Hague Conference in the fall of 1929.

Uptodate Data on Fuels

Bureau of Standards Reports on Aircraft-Engine Fuel-Requirements and Aviation Gasoline

A PROBLEM of vital importance to the aircraft-engine manufacturer, the airplane builder, the air-transport company and the petroleum-refining industry is ably analyzed in the paper now to be presented, said Chairman T. A. Peck, of the Shell Petroleum Co., in the course of his introductory remarks at the Fuel Sesion held Tuesday evening, Feb. 18. Dr. H. K. Cummings, chief of the automotive powerplants section of the Bureau of Standards, then read his paper on Gasoline Requirements of Commercial Aircraft-Engines. More than 75 members and guests greeted the author, and a prolonged discussion ensued following the paper's presentation.

The second paper was entitled, The Vapor-Locking Tendency of Aviation Gasolines. It was prepared by Dr. O. C. Bridgeman and H. S. White, of the Bureau of Standards, and was read by Dr. Bridgeman.

Fuel Requirements Outlined

In brief, Dr. Cummings said that the question of fuel requirements for any engine involves two positive and two negative demands. The gasoline should have *suitable antiknock value* and *adequate volatility*, and it should not contain an excessive amount of gum or harmful quantities of sulphur. The Federal aviation-gasoline specifications do not cover the first point for the reason that, at present, no generally accepted test or standard of antiknock value exists; but Dr. Cummings stated that progress is being made in the development of a standard knock-testing engine by a committee of the Society and representatives of the American Petroleum Institute in cooperation with the Bureau of Standards.

The 10-per cent point on the customary distillation curve of any gasoline, as determined by the method recommended by the American Society for Testing Materials, measures the volatility of that gasoline as regards engine starting and also indicates the fuel-line temperature at which vapor lock is likely to occur. The 90-per cent temperature determines the dew-point of the gasoline and serves much better than the end-point to characterize the gasoline as regards vaporization and distribution.

Aviation gasoline meeting the volatility specification for fighting grade is fully equal to average British and European aviation gasolines. Aviation gasolines made of stabilized natural gasoline are also available if a more volatile product is required.

The copper-dish test for gum is unsatisfactory and is likely to be replaced or modified as the result of investigations now in progress at the Bureau of Standards and several other laboratories. However, gasolines passing the present laboratory test will be satisfactory unless gum develops while they are in storage.

The sulphur specification permits only 0.10 per cent of sulphur, and this will certainly prevent trouble from corrosion. The Bureau of Standards hopes to undertake an investigation of corrosion to ascertain whether more sulphur can be permitted without danger as soon as Government funds are available.

Dr. Cummings pointed out that the engine manufacturer should ascertain by test the minimum antiknock and volatility requirements of his engine and be in a position to recommend suitable fuels to his customers. Several oil companies are marketing under brand names aviation gasolines so controlled as to have approximately uniform detonation and volatility characteristics throughout the Country, he said, and stated also that the adoption of such a policy by other oil companies would simplify the manufacturers' problem to a considerable extent.

Additions of Tetraethyl Lead Discussed

"Dr. Cummings' concluding statement stands out in my mind," said Chairman Peck in opening the general discussion. "If more oil companies would follow the example of those several pioneers who already have given the aircraft industry of the United States a uniform and dependable fuel throughout the Nation, the work of the aircraft-engine designers, the airplane builders and the air-transport officials would be very much simplified."

After replying to questions regarding corrosive agents other than sulphur and as to how the fuel samples referred to in his paper were selected, Dr. Cummings answered the question propounded by Anson M. Keller, of the Ryan Aircraft Corp., as to the effects of different concentrations of tetraethyl lead on the antiknock properties of gasoline for use in aviation engines. He replied that only general statements can be made, but that the effect of adding tetraethyl lead to given gasolines seems to decrease their noisability after some limited quantity has been added; however, that point of decrease ordinarily is outside the range of tetraethyl lead added. He remarked also that, so far as can be determined roughly from a given addition of lead to a given gasoline, the amount of improvement is quite different. Each case is more or less a special case, and lead is not particularly desirable as a standard criterion of how good a gasoline is. In general, Dr. Cummings thinks that, so far as can be judged, a more or less uniform benefit is obtained from small additions of lead, but, if the process of addition is continued, a point is reached at which the same increment of lead produces very little benefit.

Other questions raised, which were answered by Dr. Cummings, related to the permissible gum-content in gasolines, compression ratios, standardization of antiknock engines, fuel systems designed to use highly volatile fuel, and increase in compression ratio by suitable engine design.

Vapor-Locking Tendencies Cited

A fuel-feed system should not be designed without regard for the type of fuel which will be used, according to a statement in the introduction of the paper on the Vapor-Locking Tendency of Aviation Gasolines, by Dr. Bridgeman and H. S. White. The more volatile a fuel, the statement continued, the greater will be the tendency to boil in the fuel-feed system and, if boiling oc-

curs, interruption of flow due to vapor lock may be expected.

This investigation was undertaken as part of a fundamental study of vapor lock in airplane fuel-systems under the direction of the Research Committee of the Society, and was made possible by a contribution from the Naturaline Co. of America. The supervision of this investigation was accepted by the Cooperative Fuel Research Steering Committee in September, 1929, because of the vital importance of the vapor-lock problem to both the petroleum and the automotive industries.

After elaborating the point that fuel systems employing long suction-lifts may be subject to vapor lock at lower temperatures than those employing a straight gravity feed, the authors stated some of the precautions regarding fuel lines and fuel which should be observed to secure satisfactory airplane operation; referred to data previously given on the properties of gasolines that affect their vapor-locking tendency; and said that, from this study, it was possible to predict the conditions under which any given fuel would cause trouble from vapor lock.

They stated further that the present paper covers a second phase of the investigation in which the predicted conditions for vapor lock are compared with those actually found to interrupt fuel-flow in typical airplane fuel-feed systems. For the systems studied, they say that there is remarkable agreement between the predicted limiting conditions and those actually found in the flow experiments to cause vapor lock.

Vapor-Lock Study Outlined

An outline of the vapor-lock investigation was presented, and the predicted conditions for vapor lock were stated. From the viewpoint of the fuel, it was said that serious interruption of flow due to vapor lock under any given set of conditions is dependent upon the vapor pressure of the gas-free gasoline and upon the volume of dissolved gases liberated by the gasoline. From the study of the solubility of gases in gasolines, the conclusion was reached that the volume of dissolved gases that would be liberated in the fuel line was not sufficient to cause vapor lock in a well-designed fuel-feed system; hence the vapor pressure of the gas-free gasoline is the only essential property of a fuel which is of interest as regards vapor lock. In this work, propane was considered as one of the liquid constituents of the fuel, but if present in more than very small amounts sufficient gas might be liberated to cause serious interruption of flow.

Vapor-locking temperature was defined by the authors as being the temperature at which the vapor pressure of the gas-free gasoline becomes equal to the external pressure on the gasoline in the fuel-feed line at the point where marked vaporization occurs. The general relation between the distillation data, the external pressure on the fuel in the feed line, and the vapor-locking temperature was explained mathematically.

Airplane Fuel-Feed Systems Analyzed

In considering the fuel-feed systems used in airplanes, the authors stated that all involve the one general principle that the fuel is fed to the carbureter under pressure. The pressure may be hydrostatic, in which case the system can be classed as "gravity feed," or the pressure may be produced mechanically, in which case the system can be designated as "pressure feed." Pressure-feed systems ordinarily involve a reduction in pressure below that in the tank as the result of suction lift or suction produced by the rotating mechanism of the pump. Various combinations of these two types of system can be employed satisfactorily, as illustrated by the variety of fuel systems to be found in Army, Navy and commercial planes.

In outlining the program for the investigation of the conditions under which vapor lock occurs in fuel-feed systems, the work was subdivided into the two general phases of a study of the conditions for vapor lock in gravity-feed systems and a study of the conditions for vapor lock on the suction side of the fuel-pump.

Experimental Vapor-Lock Analyses

The most important factor tending to cause vapor lock in a gravity-feed system is a constriction in the line, such as the metering orifice, according to the authors. Other details of construction or installation, such as arrangement of T-connections, size of tubing, siphons and so on, may have an important bearing on the vapor-locking tendency but, in general, trouble from these sources can be eliminated by changes in the system. A metering orifice is, however, essential in a carbureting system, and accordingly an experimental feed-line was set up for study of the conditions under which vapor lock occurred in the line leading to the orifice. The results obtained were illustrated by a diagram and explained.

For a study of the conditions under which vapor lock occurs on the suction side of the fuel-pump, an experimental system was set up employing a standard gear fuel-pump. A diagram of this system was shown and comments made thereon.

The general conclusion reached by the authors from this study of the efficiency of a gear pump operated under various conditions is that the vapor-locking temperatures are in general lower than the values which would be predicted from vapor-pressure data and, in some cases, the differences are very marked. If the fuel system requires the use of a fuel-pump, it appears evident from the data given that the pump should be situated as nearly as possible on a level with the tank so as to have a minimum suction-lift. A lowering of the pump level from 6 to 2 ft., for example, in the case of the fuels studied, would be equivalent to raising the ceiling of the plane many thousands of feet and would materially increase the safety of operation.

Vapor-Lock Questions Discussed

Replying to a question as to what kind of vapor-pressure test is important in connection with vapor lock, Dr. Bridgeman replied that a series of fuel systems can be designed in which each will require a different kind of vapor-pressure test to get a cold correlation. In such cases, he said, the fuel system can be redesigned so that

(*Continued on p.* 388)

FUELS-SESSION CHAIRMAN AND SPEAKERS

Dr. O. C. Bridgeman (Left), of the Bureau of Standards, Read the Paper on Vapor-Locking Tendencies of Aviation Gasolines, Written by Himself and H. S. White; T. A. Peck (Center), of the Shell Petroleum Co., Chairman of the Session; Dr. H. K. Cummings (Right), of the Bureau of Standards, Presented His Paper on Gasoline Requirements of Commercial-Aircraft Engines

Chronicle and Comment

Society's 25th Anniversary Celebration

PLANS are going forward for the suitable celebration of the completion of the first quarter century of the Society's existence. This celebration of the Silver Anniversary is to be in conjunction with the 1930 Summer Meeting at French Lick, Ind., from May 25 to 29, inclusive. A major feature is to be a pageant showing the development of automotive vehicles during the last 25 years. The making of arrangements for this is in the hands of a competent committee.

The planning of the various technical sessions of the Summer Meeting has been assigned to the several Professional Activities cooperating with the Meetings Committee, which may be expected to choose subjects and speakers with a view to appropriateness to the occasion.

Every effort is to be made to make this celebration the greatest event the Society has ever held and a fitting demonstration of its accomplishments up to the present and its greatly expanded activities during the last few years.

Reservation blanks for hotel accommodations will be sent to the members of the Society in the near future, and they will be kept informed of the development of plans through THE JOURNAL and Meeting Bulletins.

The Busiest Meetings Year

THE 1929-1930 meetings year of the Society is the most active in the history of the organization and is indicative of the rapid developments in all the automotive industries. Aeronautics is in the forefront in this respect.

At the present stage in both the aeronautic and motorboat industries, standardization looms large as the means of accomplishing greater safety, comfort and efficiency and economy of production and operation. The great strides that have been made in the automobile field through standardization of materials, parts and fittings, without impeding originality of design, serve as an incentive for like efforts in the other automotive fields.

Research work on fuels and riding comfort is producing most interesting and valuable information, and progress reports are presented at frequent National meetings. The work on fuels is applicable alike to aircraft and road vehicles.

The economics of production is becoming more difficult and is beginning to call for a high order of engineering mathematics and management. A new field for well-trained men is opening and the Production Meetings and production activities of the Society provide the opportunity to keep in step with the movement.

Operation and maintenance engineering in connection with motorcoach and motor-truck fleets is rapidly assuming an importance comparable with that of design and production engineering. More and longer meetings are therefore required for the consideration of methods and problems related to the subject.

National meetings now scheduled for the remainder of this year are listed in the Meetings Calendar on p. 300. Besides these National meetings, the 19 Sections of the Society are holding regular monthly meetings at which many excellent papers are presented and discussed.

Thus, every opportunity is afforded to members to keep fully informed, not only on the latest advances that have been made in all the fields of the Society activities, but on the probable trend of development for several years to come. Attendance at as many of the meetings as possible is one of the surest ways of acquiring knowledge bearing on a member's immediate work.

Aeronautic Meetings of the Society

THE Aeronautic Meeting held by the Society in St. Louis during the International Aircraft Exposition, Feb. 18, 19 and 20, was one of the most successful so far conducted. The registration list is a roster of prominent engineers and executives in the aeronautic industry, the largest percentage of whom are active, interested members of the Society.

Further similar meetings have been scheduled in connection with the major aeronautic events of interest. The first of these will be held on April 8, 9 and 10 at the Book-Cadillac Hotel, Detroit, during the All-American Aircraft Show. The Metropolitan Aeronautic Meeting is scheduled for May 7, during the New York Aviation Show, and will be followed in the evening by a large aeronautic banquet.

Additional meetings are to be held the last week in August in Chicago at the time of the National Air Races and on the Pacific Coast in conjunction with the Western Aircraft Exposition some time in the autumn.

The 1930 Handbook

THE 1930 edition of the S.A.E. HANDBOOK will be mailed to members about April 1. This edition, besides including standards and recommended practices approved by the Standards Committee in June, 1929, and published in the Supplement to the 1929 edition, contains new and revised specifications approved in January. A significant feature of the 1930 edition is the 78 pages of aeronautic standards illustrating the activity of this industry in setting up such standards as are possible while still in its infancy, which will result in greater benefit than was thus obtained by the automobile industry in its early years.

Members who fail to receive their 1930 HANDBOOK within a reasonable time after April 1 should notify the Standards Department of the Society.

The 1930 Roster Being Mailed

COPIES of the Membership Roster of the Society for 1930 are being mailed this month to all members who have requested them. If any member who has requested the Roster fails to receive it in due course, the New York City offices of the Society will appreciate being informed of the fact.

Flight-Test Instruments[1]

By J. B. PETERSON[2] AND E. W. ROUNDS[3]

ST. LOUIS AERONAUTIC MEETING PAPER — *Illustrated with* CHARTS AND PHOTOGRAPHS

TO OBTAIN accurate results in the flight testing of airplanes, the testing methods must be carefully planned with this object in view. The proper selection and use of instruments is an important part of the program. It is the object of this paper to discuss certain instruments and methods which are at present used by the Flight-Test Section of the Navy Department. The Bureau of Standards has for a number of years cooperated with the Flight-Test Section in the development, testing and calibration of flight-test instruments.

Routine flight-tests involve the determination of maximum rates of climb and high, low and cruising speeds at different altitudes[4]. These characteristics are determined by the measurement of time, air pressure, air temperature, air speed, engine revolutions per minute and fuel consumption. The instruments for measuring these quantities and methods for their calibration and use will be discussed in detail.

In the flight-testing of aircraft, the proper selection and use of instruments is essential. In this paper the authors discuss, in detail, instruments and methods for measuring air pressure, air temperature, air speed and engine speed. The errors or altimeters, barographs, air-speed indicators and tachometers are defined, and the magnitude of the errors of typical instruments are shown graphically.

Instrument Errors

Before describing the individual instruments used in flight tests, it is thought advisable to define and classify the errors usually found in such instruments as altimeters, barographs, air-speed indicators and tachometers. Errors of these instruments may be divided into three classifications: (*a*) scale errors; (*b*) elastic errors, including hysteresis, drift and after-effect; and (*c*) temperature errors.

The scale error is defined as the deviation of the reading from the correct value under definite test-conditions (a specified rate of change in reading at a specified instrument temperature). The hysteresis error is the difference in error for increasing and decreasing readings, the change in reading being at a specified rate. Drift and after-effect will not be discussed here except to state that they are caused by imperfect elasticity, as is hysteresis.

Large hysteresis is accompanied by large drift and after-effect, and vice versa. Friction may be partly responsible for these errors, but the vibration of the instruments on the instrument board of an airplane is such that slight friction will not usually affect the reading. In making laboratory tests the usual practice is to tap the instrument before each reading so as to eliminate the effect of friction.

Temperature errors are defined as the change in reading due to a change in instrument temperature. They are caused principally by a change in stiffness of the elastic parts of the instrument and to a lesser extent by the thermal expansion of parts. The curves of Fig. 1 show the magnitude of errors to be expected for altimeters, barographs, air-speed indicators and tachometers. The errors shown are for modern instruments such as would meet Army or Navy specifications.

The scale error is the only one of the three errors just enumerated for which corrections are normally applied. This is partly because the application of hysteresis and temperature corrections is difficult and unreliable and partly because these errors are so small for the better instruments that they may be neglected. However, only instruments with low hysteresis and temperature errors, as determined by laboratory tests, should be used.

The laboratory apparatus for the determination of scale corrections for altimeters, barographs and tachometers is not costly or complicated, and only by its use can the accuracy of results obtained by these instruments be assured. Methods recommended for testing each of these instruments are given under the heading of the individual instrument.

Air Pressure

Either an altimeter or a barograph may be used to determine the air pressure. Use of a barograph is definitely recommended when it is necessary in a single-place airplane for the pilot to take readings of all instruments. The reading of the altimeter on a climb requires more attention than the reading of any other instrument, as the pressure is changing rapidly and it is important that the readings be accurately timed. Usually, the pilot, when relieved of this duty, can get satisfactory readings on the other instruments. For testing single-place airplanes, the use of recording thermometer, air-speed meter and tachometer would be very desirable. These instruments are, however, not as reliable as barographs and are seldom used.

The altimeter is graduated in altitude units in ac-

[1] Published by permission of the Director of the Bureau of Standards of the United States Department of Commerce, City of Washington.

[2] Associate engineer, Bureau of Standards, City of Washington.

[3] M.S.A.E.—Flight Test Section, Bureau of Aeronautics, Navy Department, City of Washington.

[4] See The Reduction of Airplane Flight-Test Data to Standard Atmosphere Conditions, by Walter S. Diehl and E. P. Lesley; N.A.C.A. Technical Report No. 216 (1925); also Engineering Aerodynamics, by Walter S. Diehl; Ronald Press Co., 1928.

cordance with the altitude-pressure relation of the United States standard atmosphere. Modern instruments are provided with an index mark for setting the dial so that the instrument indicates zero altitude at a pressure of 760 mm. of mercury. This setting should be used in flight tests. If the altimeter is set to read zero on the landing-field, the subsequent readings are functions of the pressure at both the landing-field and the level of the instrument. Corrections for the altimeter should be determined frequently by comparison with a mercury barometer in the laboratory.

Marked improvement has been made in the elastic properties of altimeters in the last few years. The scale errors, hysteresis and temperature errors to be expected in modern instruments are shown in Fig. 1. To obtain the altimeter data in Fig. 1, the pressure was changed at a rate corresponding to an altitude change of 2000 ft. in 5 min.

The 20,000-ft. altimeter, the errors of which are plotted in Fig. 1, has a pointer which makes two revolutions for the 20,000-ft. range. The open scale is especially useful when it is desired to fly level to determine maximum speed.

The modern altimeter is provided with an air-tight case and a fitting for connecting it to a properly located static opening, thereby eliminating the errors due to the difference in cockpit or cabin pressure and free-air pressure. This error is 50 or 100 ft. in open-cockpit airplanes and may be more for cabin airplanes. For open-cockpit airplanes the altitude indication is higher than it should be, that is, the error is positive[5].

The use of a barograph such as is illustrated in Fig. 2 has proved to be most satisfactory for recording air pressures. The pressure element consists of a seamless metal bellows or sylphon, with enclosed steel spring. The instrument is available with either single or dual-traverse mechanism. For ranges above 20,000 ft., the dual-traverse mechanism is recommended. For rate of climb determination, the record cylinder should make a revolution in not more than 2 hr.

The smoked-chart method of recording offers several advantages, among which are (*a*) reliability at low temperature, (*b*) small scriber friction and (*c*) fineness of record line. Gum camphor is burned to smoke the chart. After the flight the chart is fixed by immersion in a solution of 1 part collodion and 3 parts of the thinner commonly used with nitrocellulose lacquers.

It has been found practical to calibrate the barograph by placing it under a bell jar and decreasing the pressure in steps to make a chart, a section of which is illustrated in Fig. 3. The pressure corresponding to each step is read from a mercury barometer connected to the bell jar. For this test it is essential that the bell jar and barometer system be absolutely air tight so that the pressure remains constant for the duration of the step. After the chart is fixed, the distance from the bottom of the chart to each step is carefully measured. With a good scale the measurement can be determined to the closest 0.01 in. A calibration curve, a portion of which is shown in Fig. 4, is constructed from the measurements thus obtained.

If the reversing point of one of these charts is carefully examined, it will be seen that the reversal for a constant rate of climb is not sharp. There is a horizontal section which, for some instruments with a slow rate of change in pressure, may be as much as $\frac{1}{8}$ in. long. This means that the pressure at which the scriber reached the reversing level was not the same as the pressure at which it left the reversing level.

[5] See The Variation in Pressures in the Cockpit of an Airplane in Flight, by Thomas Carroll and William H. McAvoy; N.A.C.A. Technical Note No. 300 (1928).

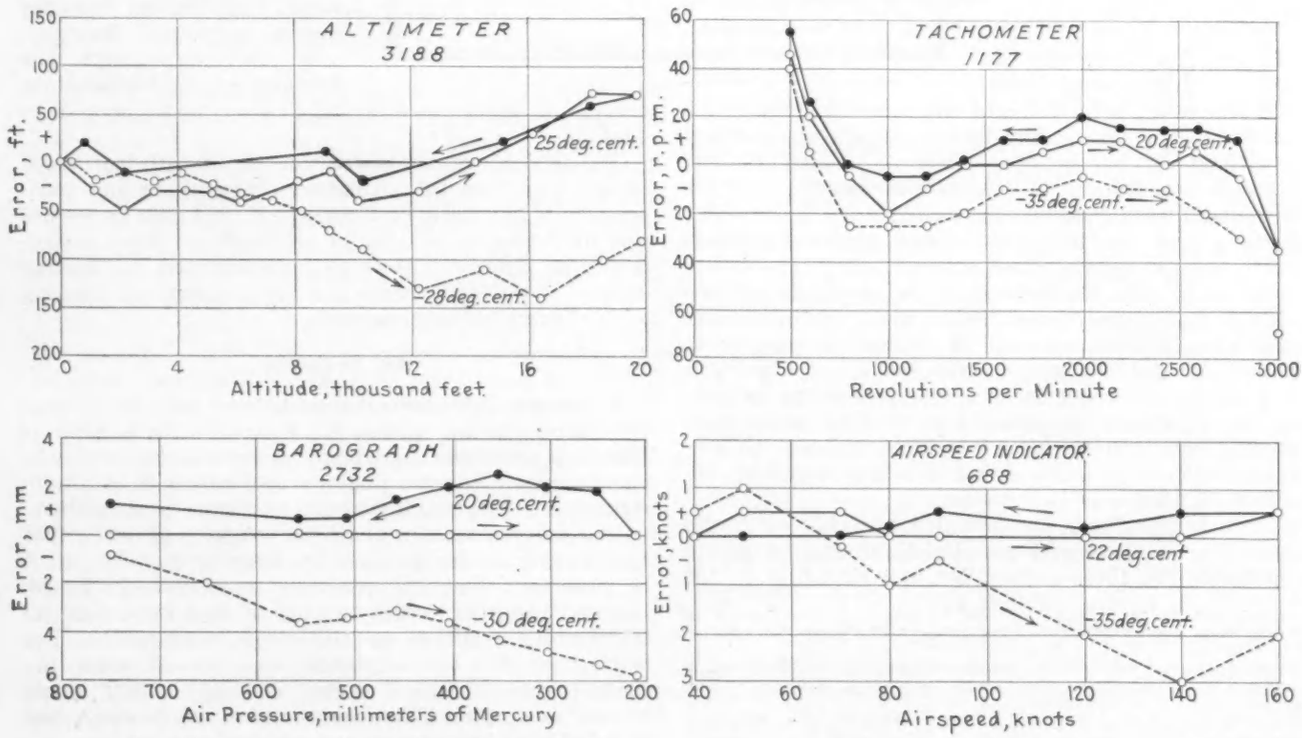


FIG. 1—FLIGHT-TEST INSTRUMENT ERRORS

This causes the calibration curves of Fig. 4 to cross below the reversing level. It is important that calibration steps be taken at pressures just below and just above the reversing point; otherwise, the extrapolation of the calibration curves of Fig. 4 below the last points may not be accurate. The reversal on the chart shown was purposely made rather broad to illustrate this point.

For use at very low temperatures, below —20 deg. cent. (—4 deg. fahr.), it is necessary to take special precautions to assure that the barograph clockwork will continue to function. An investigation of the possible causes of trouble on this score disclosed the fact that the oil in the clock mainspring solidified at low temperatures. The substitution of a mixture of low-temperature oil and graphite for the oil previously used has given perfect performance.

For highest accuracy at very low temperatures, such as may be experienced at high altitudes, the use of an additional scriber for recording the instrument temperature is recommended. The attachment, which may be seen on the base of the instrument in Fig. 2, consists of a bimetallic spiral actuating a scriber to record the instrument temperature on the same chart with the pressure. After the flight, a flight-history test is made in the laboratory, in which the actual pressures and temperatures as recorded are duplicated and measured with laboratory apparatus. It should be remembered that this attachment records the temperature of the barograph and not the temperature of the free air. On a climb, the temperature of the free air may easily be 20 deg. cent. (68 deg. fahr.) lower.

These barographs hold their calibration exeedingly well over a period of months. It has been found desirable to solder the zero-adjusting thumb-nut on the pen arm so that it will not turn under the effect of vibration. Care must be taken also to see that no adjustment on the scriber or the small control-springs in the mechanism is made between the calibration and the flight test.

The barograph should be suspended on shock-absorber cord to insulate it from mechanical vibrations and shocks. Space in the baggage compartment or in the fuselage behind the cockpit is usually available for this purpose. When the barograph is fastened rigidly to the plane, the vibration is likely to cause the scriber to make a wide indefinite trace.

[6] See Lag of Thermometers and Thermographs for Aircraft, by H. B. Henrickson and W. G. Brombacher; *Monthly Weather Review*, vol. 55, 1927, p. 72.

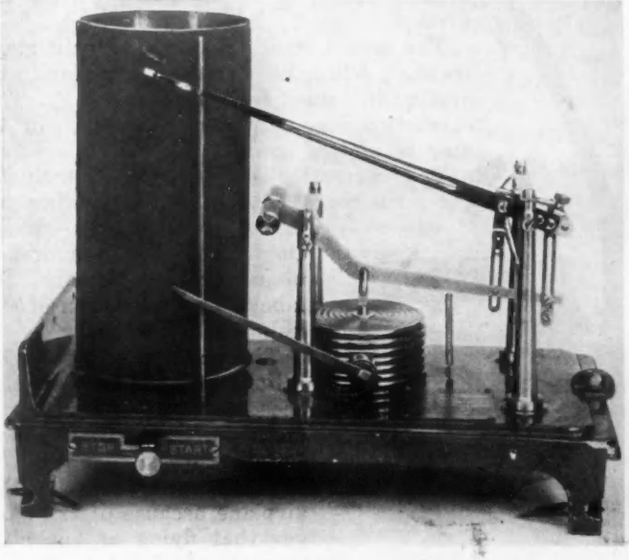


FIG. 2—FRIEZ DUAL-TRAVERSE BAROGRAPH

FIG. 3—SECTION OF BAROGRAPH CHART

Air Temperature

The accurate measuring of air temperature is complicated by the comparatively rapid rate of change of temperature and the necessity of getting away from the engine to measure the actual free-air temperature. The ordinary liquid-in-glass type of strut thermometer, shown at the left in Fig. 5, meets the latter requirement. These thermometers have a wide red-liquid column and can be read at distances up to 15 or 20 ft. This type of strut thermometer has two distinct disadvantages; first, on some airplanes, especially monoplanes, it is not convenient to mount the thermometer so that it can be seen from the cockpit; and second, the lag in indication may cause an appreciable error on a fast climb during which the temperature is changing rapidly[6]. It should be pointed out here that the installation of this type of thermometer may increase the drag of a small, fast airplane appreciably. To avoid any question on this score, it may be advisable to make the high-speed trials without this test instrument.

For the use of the Flight Test Section of the Navy Department, the Bureau of Standards has developed an electric-resistance thermometer that eliminates all of these disadvantages. The time-lag of this instrument in an airstream of 80 m.p.h. is only 2 sec., as compared with 25 sec. for the liquid-in-glass type. Assuming a climb of 2000 ft. per min. in the standard atmosphere, the time-lag error for the electric-resistance thermometer would be 0.1 deg. cent. (0.18 deg. fahr.), while that of the liquid-in-glass type of instrument would be 1.6 deg. cent. (2.88 deg. fahr.). For airplanes having a lower rate of climb, the lag error is reduced and the liquid type of thermometer is usually satisfactory.

The temperature element of any thermometer that may be used should be protected from the direct rays of the sun. Shielding for each of the thermometers mentioned is built into the instrument.

At the right in Fig. 5 is shown the electric-resistance thermometer with a dismantled temperature element. The temperature element is mounted on a strut or at any convenient place away from the engine where it will get free circulation of the air. A duplex cable, part of which is shown, leads to the instrument in the

cockpit or cabin. Current is provided by two No. 6 dry-cells in a thermally insulated battery-box.

The circuit is a Wheatstone bridge which is balanced when the temperature element has a temperature of 20 deg. cent. (68 deg. fahr.) and a resistance of 50 ohms. The rheostat at the upper right-hand corner of the instrument must be adjusted occasionally to compensate for changes in battery voltage. The switch in the upper left-hand corner, when placed on the test position, changes the circuit so that the voltage can be properly adjusted by setting the instrument pointed on +20 deg. cent. (68 deg. fahr.).

Air Speed

The use of a pitot-static air-speed indicator is recommended, but its calibration over a speed course is essential. This is because of the interference of parts of the airplane with the flow of air around the pitot-static head. The speed course should have a length of at least two miles. The ends should be clearly defined and the flying should be done at a low altitude so that the time of transit between the ends of the course can be determined accurately by means of a stop-watch carried on the airplane.

The speed determined by dividing the length of the course by the time of transit we shall call the ground speed. The effect of a steady wind parallel to the course is balanced out by taking the average of the ground speeds in two directions. The average time of transit should not be taken, as this method will give erroneous results. If there is a component of the wind perpendicular to the course, the plane should be flown so that its longitudinal axis is always parallel to the course. The cross wind will then drift the plane off the course but, if the stop-watch is operated when the airplane comes opposite the marker at the end of the course, correct results will be obtained.

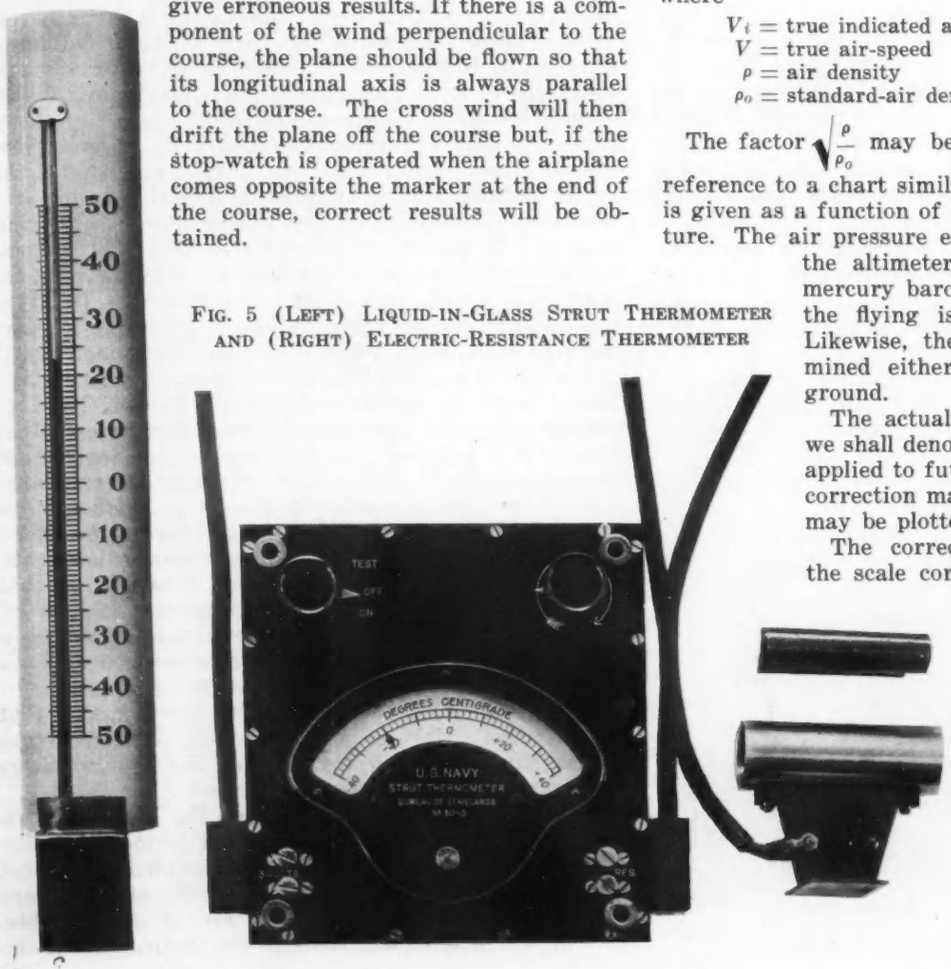


FIG. 5 (LEFT) LIQUID-IN-GLASS STRUT THERMOMETER AND (RIGHT) ELECTRIC-RESISTANCE THERMOMETER

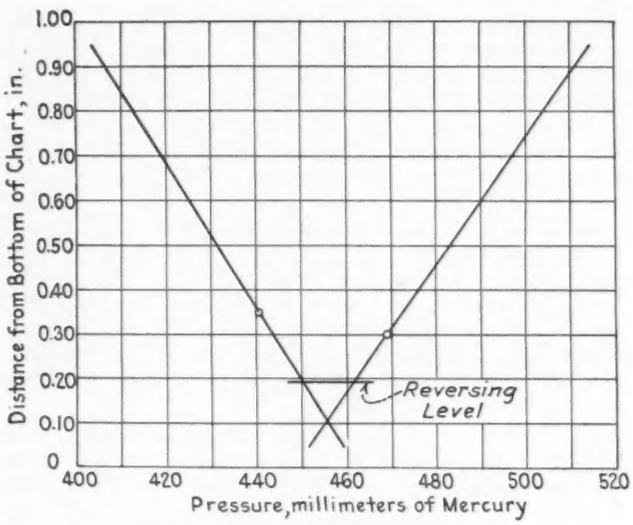


FIG. 4—SECTION OF BAROGRAPH CALIBRATION-CURVE

The average ground speed is the true air-speed of the airplane. The pitot-static indicator, assuming a perfect instrument free from strut interference, should have an indication V_i determined by the following equation

$$V_i = V\sqrt{\frac{\rho}{\rho_o}} \qquad (1)$$

where

V_i = true indicated air-speed
V = true air-speed
ρ = air density
ρ_o = standard-air density

The factor $\sqrt{\frac{\rho}{\rho_o}}$ may be conveniently determined by reference to a chart similar to Fig. 6, where the factor is given as a function of air pressure and air temperature. The air pressure even may be determined from the altimeter on the airplane or from a mercury barometer at the landing-field, as the flying is done close to the ground. Likewise, the temperature may be determined either on the airplane or on the ground.

The actual indication of the instrument we shall denote by V_a. The correction to be applied to future readings is $V_i - V_a$. The correction may be plotted against V_a or V_i may be plotted against V_a.

The correction as determined includes the scale corrections of the indicating instrument as well as corrections due to the interference of parts of the airplane. No laboratory calibration of the indicator is necessary.

The installation should be calibrated at about five air-speeds. The speed-course method should not be used for the lowest point at or near the stalling speed of the airplane because of the danger that flying at low altitudes would involve. Either

of two methods may be used for the calibration at the lowest speed. The indication may be compared to the indication of an instrument connected to a trailing pitot-static head. The trailing head is suspended at a sufficient distance below the airplane so that the airplane will not disturb the air through which the trailing head is passing. It is assumed that the trailing head has been calibrated and its corrections are known.

In the second method, a slower airplane with a lower stalling-speed is flown in formation with the plane under test. A comparison of air-speed readings gives the required correction, provided the corrections for the indicator of the slower airplane are known.

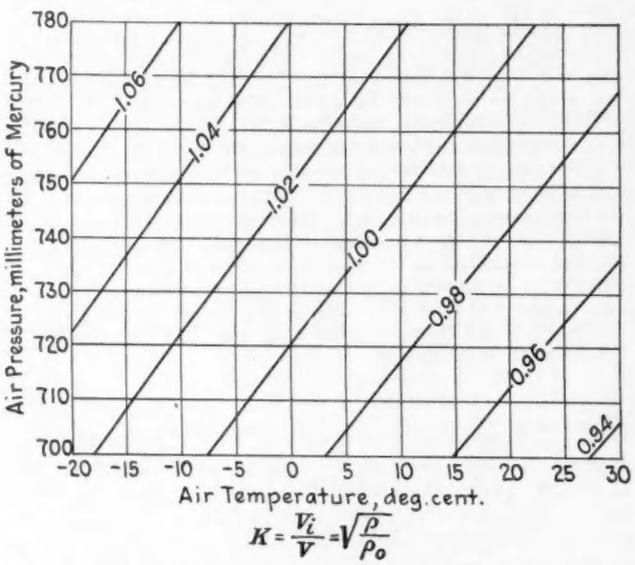


FIG. 6—DENSITY CORRECTION FOR SPEED-COURSE CALIBRATION OF AIR-SPEED INDICATOR

Engine Speed

Most performance tests are run at full-open throttle and the tachometer serves only to inform the pilot if the condition of the engine is such that it is performing at its proper speed. The accuracy required may be estimated if we remember that the speed of an airplane in level flight will vary directly as the propeller revolutions per minute for small variations from normal revolutions per minute.

Among the tachometers which could be recommended for performance testing, the chronometric and centrifugal are the two types in general use. The chronometric is at present the most accurate and reliable, but the centrifugal instrument is more durable and its accuracy is being steadily improved. The tachometer errors shown in Fig. 1 are for a centrifugal instrument.

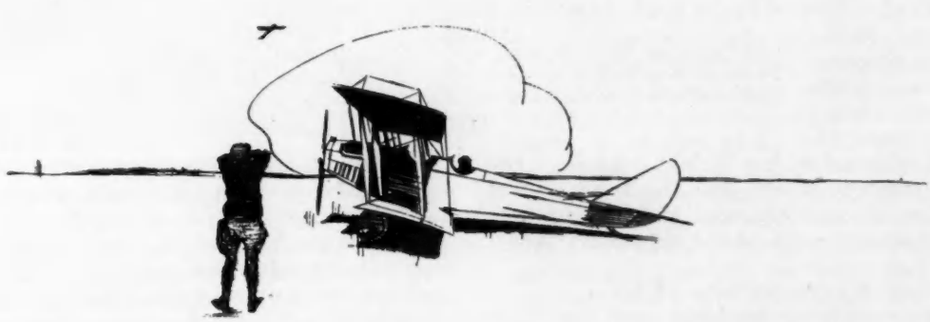
Of the instruments discussed in this paper, the tachometer is the most liable to change of calibration with use, and for this reason laboratory checks are indispensable. When only a few instruments are to be checked, an electric motor may be used to drive the instrument at a constant indicated speed while the actual speed is measured by means of a revolution counter and a stop-watch. The addition of a flywheel on the motor shaft facilitates the maintenance of a constant speed. A light pressure of the hand on the rim of the flywheel acts as a brake to exactly regulate the speed.

Fuel Consumption

It is hoped that some day a satisfactory fuel flowmeter will be developed, but at present the determination of fuel consumption by the measurement of quantity of fuel in the tank before and after a test run is the preferred method. This method has the advantage that the installation of special apparatus for the test is not required.

If there are two fuel tanks with valves for switching from one to the other, the procedure is very much simplified and results are more accurate. All maneuvering before and after the actual test is done on fuel from the main tank, and the test run is made on that from the auxiliary tank. The quantity of fuel required to fill the auxiliary tank after the flight is then the quantity consumed. If this method is used for determination of fuel consumption in level flight, the test run should have a duration of about 15 min.

If there is only one fuel-tank, the airplane is climbed to the altitude at which it is desired to make the test, the engine is throttled and the airplane glided back to the landing-field. The quantity of fuel consumed on this tare run is determined by measuring the quantity required to refill the tank. The climb is then duplicated as closely as possible. When the altitude is reached, the test run is made and the airplane is glided back to the landing-field as before. The consumption on the test flight, minus the consumption on the tare flight, is the quantity desired. The level flight for a test conducted in this manner should have a duration of 1 hr.



Flying an Airplane in Fog

By James H. Doolittle[1]

St. Louis Aeronautic Meeting Paper — *Illustrated with* Photographs

EXPERIMENTS conducted by the Daniel Guggenheim Fund for the Promotion of Aeronautics to determine the feasibility of flying an airplane by instruments alone are described. In conducting these tests, a Navy training airplane that was practically standard as regards design and equipment was used. In addition to the standard engine and navigating instruments, the airplane was equipped with an aircraft radio-receiver and transmitter and a vibrating-reed indicator. Additional ground radio equipment consisted of audible and visual types of radio beacon and a ground receiving and transmitting set.

Upon approaching the airport, the airplane followed the beam of an audible-type radio-beacon until the point of intersection of the audible and the visual-type beacon-beams was reached. At that point the pilot would request, by radio, data on pressure, wind and visibility conditions at the landing-field and follow along on the localizer beam until he landed.

While instruments have been developed and are readily available whereby a pilot can fly indefinitely without being able to see outside of the cockpit and can land at any desired point provided it is prepared for instrument landing, instrument flying is still in a highly experimental stage. However, when the method described in the paper or some improvement thereon is developed to the point of commercial application, the airplane will become the safest means of transport, since it will be the only one that fog does not hamper in operation.

THE time has come when no airplane is thoroughly equipped that cannot be flown by instruments alone; that is, permit the pilot not only to retain complete control of the airplane, but also to direct it to any desired point regardless of weather conditions. Furthermore, no pilot has completed his training until he has learned to fly an airplane by instruments alone without the need of any outside reference point. With the instruments now developed and readily available, a pilot can fly indefinitely without being able to see outside the cockpit. He can leave any given point, arrive at any desired destination and land at any desired point after arriving provided the terminal field is prepared for instrument landing.

Test Airplane

In the experiments[2] conducted by the Daniel Guggenheim Fund for the Promotion of Aeronautics, the equipment employed was an NY2 Consolidated Navy training airplane, which is shown in Fig. 1, equipped with a Wright J-5 engine and standard in all respects except that the fuselage was faired to improve the performance and an oleo-type landing-gear and wheels replaced the old rubber shock-type. The airplane was equipped with standard engine and navigation instruments, including tachometer, oil-pressure gage, oil-temperature gage, ammeter, voltmeter, compass, bank-and-turn indicator, air-speed indicator, altimeter and rate-of-climb indicator, a view of the instrument board being presented in Fig. 2. In addition to these, a Kollsman barometric altimeter (Fig. 3) with a range of 20,000 ft. and graduated in 10-ft. intervals, a Sperry artificial horizon and a Sperry directional gyroscope were used. The sensitive altimeter was synchronized with another one located on the ground and kept in adjustment through two-way radio communication between the ground and the airplane. In this way any apparent change in ground altitude, due to change in barometric pressure, was immediately corrected for on the airplane altimeter. The artificial horizon gave at all times the altitude of the airplane with respect to a true horizon, the different indications being shown in Fig. 4.

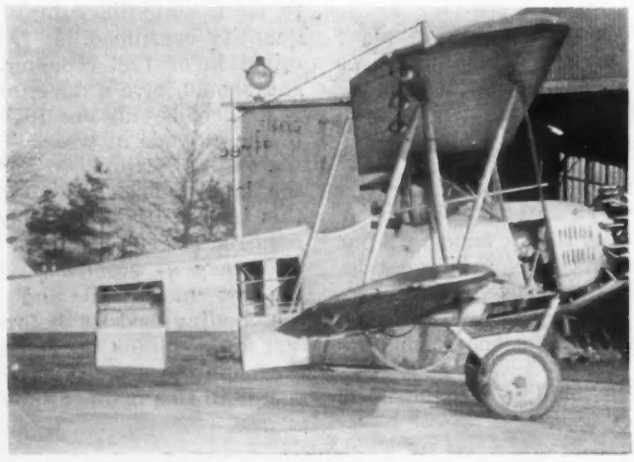


Fig. 1—Navy Training Airplane Used in the Experiments

This Airplane Was Standard in All Respects Except That the Fuselage Was Faired To Improve the Performance and the Old Rubber Shock-Type Landing-Gear and Wheels Were Replaced by the Oleo Type

The directional gyroscope permitted the pilot to hold a steady course or to change his course by any desired amount. The directional gyroscope is not truly a gyroscope compass because it is not north-seeking. When synchronized with the magnetic compass it holds its position over a considerable time. In some tests it held remarkably well; in others poorly. For instance, during a flight from Buffalo to New York City the directional

[1] Technical adviser, Shell Petroleum Corp., St. Louis.

[2] These experiments are to be published in a report that is now in process of preparation for the Daniel Guggenheim Fund for the Promotion of Aeronautics.

gyroscope did not change an appreciable amount over a 2-hr. period, and then acquired a considerable error in the next hour. This difficulty was attributed in part to a slight end-play in the rotor bearings which permitted a slight shifting of the rotor center of gravity with reference to the gimbals.

In spite of not holding a course indefinitely, the directional gyroscope has three very great advantages over any other directional instruments for airplanes. In the first place, it is not affected by rough air and its precessional error is so slow that an absolutely straight course can be held by occasionally checking against the compass and setting off the proper correction. In bad weather or when flying blind, an absolutely straight course can be kept while the compass steadies down. The third advantage is that changing a course by any desired amount is possible. This is very difficult with a magnetic compass, especially when heading toward the north.

The airplane was equipped with a Radio Frequency Laboratory standard aircraft receiver (Fig. 5) and vibrating-reed indicator. This permitted the reception of signals from the audible and the visual-type beacons and the voice. Two transmitters were employed, one a Western Electric voice-type and the other a Radio Frequency Laboratory code-type. Our experience showed that either type was satisfactory as an aid to landing in fog, provided a wing-tip antenna was used.

The trailing-wire antenna was found to be out of the question, owing to the inconvenience experienced and time required to let it out and to reel it in upon approaching the field. An automatic reel that would operate by the mere pressing of a button or throwing a switch might solve the problem. The trailing-wire antenna has the advantages that it gives greater range of reception and that a longer wave-length can be employed.

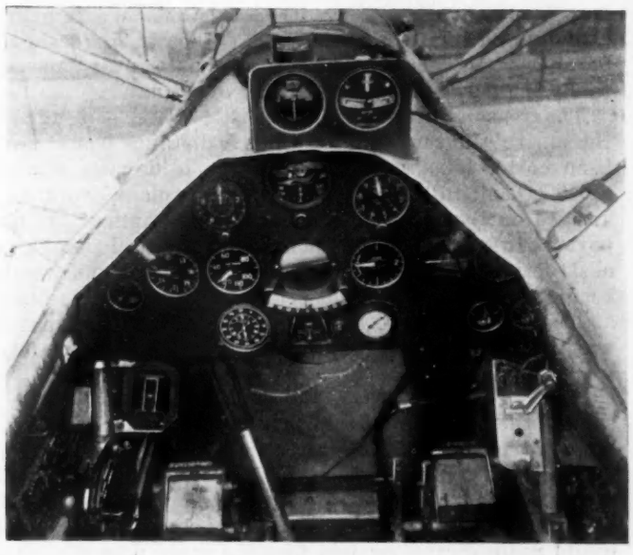


FIG. 2—INSTRUMENT BOARD OF THE AIRPLANE
Standard Engine and Navigation Instruments Were Used

The ground radio equipment consisted of (*a*) an audible-type radio-beacon belonging to the Army, the purpose of which was to direct the incoming airplane to the vicinity of the field or to keep an outgoing airplane on its course; (*b*) a visual-type localizer-beacon, the function of which was to lead the pilot to the exact point where he should touch his wheels in landing; and (*c*) a ground receiving and transmitting set.

FIG. 3—KOLLSMAN BAROMETRIC ALTIMETER
This Instrument Had a Range of 20,000 Ft. and Was Graduated in 10-Ft. Intervals

The method employed was to taxi the airplane out onto the field in position for take-off and on the beam. The altimeter was set at zero. The directional gyroscope was set so as to read the same as the magnetic compass and the engine held wide open until the various venturi-driven gyroscopic instruments came up to speed. During this time the pilot held the airplane stationary. Then the brakes were released and a take-off executed, holding the airplane straight and the wings level by the indicator on the directional gyroscope, and the tail in the proper attitude by the artificial horizon. The axis of the gyroscopic element in the directional gyroscope gave a very good indication of the longitudinal attitude of the airplane on a north-and-south course and of the lateral attitude on an east-and-west course.

The localizer beam was followed for about four miles. During this time the airplane was gradually climbed to about 1000 ft. A 180-deg. turn was made at this point and the beam followed to the beacon. As the beacon was approached, the beam became narrower and, while it was more difficult to follow, the course became much more exact.

The visual-type indicator, consisting of two vibrating reeds, indicated to the pilot his position with respect to the beam center. When to the right of the beam, the right reed vibrated through a greater amplitude. When to the left of the beam, the white smear caused by the vibration of the left reed became longer than that of the right. When exactly over the center of the beam path, the reeds vibrated with equal amplitude. Upon approaching the beacon house, the intensity of the signal increased rapidly and reducing the volume became necessary. At the exact moment of passing over the beacon house, the reeds stopped momentarily and then started to vibrate again in the opposite direction.

At this point, as after the first 180-deg. turn, the reed box was removed, turned upside down and reinserted in its container. The beam was followed for about four miles from the field again, but this time in the opposite direction. Another 180-deg. turn was made and the field again approached along the beam path. Altitude was gradually lost until at 400 ft., which was ample to clear all ground obstructions in the vicinity

of the field, the airplane was again leveled out and a course toward the beacon house followed. This time extreme care was exercised to follow the exact center of the beam and avoid the natural tendency to fly a zig-zag course rather than a straight line.

The course was held by the directional gyroscope and the necessary slight changes in course made from time to time. In this case, knowing the exact direction of the beam facilitated the work, as it was immediately known when a wrong direction was being flown, even though the reed indicator showed that the pilot was on his course. When the directional gyroscope and the vibrating-reed indicator both showed that the pilot was on his course and proceeding in the right direction, all that was necessary to arrive at exactly the desired point was merely to hold this course or vary it slightly.

In previous tests where the directional gyroscope was not employed, we found that following the beam into the field was extremely difficult, as the tendency when the beam narrowed down was to fly out of the beam continually on one side or the other, and difficulty was always experienced in getting back on the beam without completely recrossing it.

Upon passing over the beacon house again, the reed stopped vibrating and at this point the engine was throttled, an air-speed of 60 m.p.h. maintained and the airplane held with the wings absolutely level.

Previous experience had shown that, if the rate-of-climb indicator did not indicate a rate of the descent in excess of 600 ft. per min., the airplane could be flown

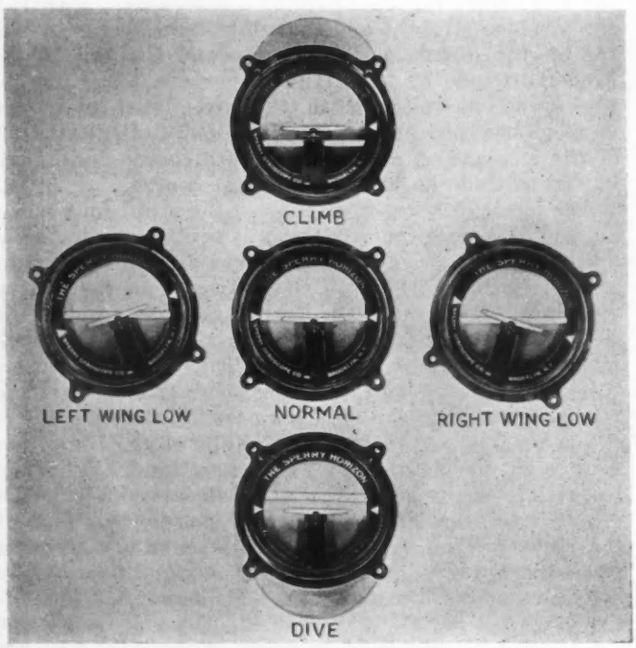


FIG. 4—THE SPERRY ARTIFICIAL HORIZON

This Instrument Indicated to the Pilot at All Times the Altitude of the Airplane with Respect to a True Horizon

directly onto the ground and the landing-gear would absorb the shock of landing without difficulty. When the rate of descent was greater than 600 ft. per min. or the landing speed exceeded 60 m.p.h., the shock of impact was uncomfortable and the airplane bounced considerably. This was caused by the oleo bottoming and the

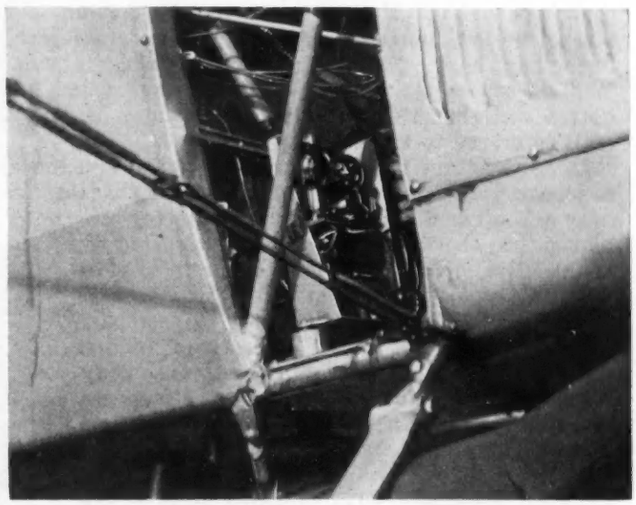


FIG. 5—AIRCRAFT RADIO-RECEIVER

Other Radio Equipment on the Airplane Included a Vibrating-Reed Indicator and Code and Voice Types of Transmitter. Receiving Signals from Audible and Visual Beacons, Sending of Code and Oral Messages and Receiving the Latter Were Thus Made Possible

rubber shock-absorber causing the recoil. With a properly designed long-travel oleo-type landing-gear, an airplane could be flown onto the ground at rates of descent considerably in excess of 600 ft. per min.

At 50-ft. altitude, the throttle was opened slightly to a previously determined mark on the throttle segment and the engine speed rose to about 1050 r.p.m. The air-speed was still held at 60 m.p.h. and the slight throttle opening flattened the glide out until, upon landing, the rate-of-climb indiator was showing about 400 ft. per min. instead of about 1000 ft., which was the rate of descent during the glide with power off. We found in some of the tests that below 50 ft. the air-speed should be allowed to decrease slightly so that the airplane actually landed at about 55 instead of 60 m.p.h.

The reason for not using a little power throughout the entire glide was that too much distance would have been covered between the time the glide was started at 400-ft. altitude and the time the airplane eventually arrived on the ground. This would be particularly important in getting into a small field and, even though no obstructions were encountered, some other signal would be required when the pilot crossed the edge of the field at a smaller altitude, say 50 ft., to inform him that it was then safe to land and that he must land immediately.

Procedure when Approaching a Fog-Bound Field

Had the airplane actually been coming into a fog-bound airport from a distant point, it would have come in along the Army audible-type beacon until arriving at a point which indicated the intersection of the audible and visual-type beacon-beams. At this point the pilot would radio in and request that the more powerful beacon be shut down to avoid interference. He would then follow on along the localizer-beacon beam and at the same time request the ground barometric pressure, wind direction, ceiling and visibility under the fog. Next, the pilot would set off the correct ground pressure on his altimeter and put himself in the proper position to land into the wind and along the beam. Unless

(*Concluded on p.* 345)

Radio in Air-Transport Operation

By HERBERT HOOVER, JR.[1]

ST. LOUIS AERONAUTIC MEETING PAPER

MR. HOOVER discusses herein the broad aspects of the situation at present existing with respect to radio reception on airplanes in flight and two-way communication with ground stations.

Safety of aviators and success of air transportation are dependent upon the fullest use of the radio, and the assertion is made that probably within a few months the Government will require transport airplanes to use radio as a matter of public policy.

In little more than a year of intensive application, many of the problems have been solved and suitable apparatus developed, and the Airways Division of the Department of Commerce has installed or is erecting about 40 ground stations at approximately 200-mile intervals along airways extending over the Country from New York City to San Francisco and from Seattle to Key West for broadcasting weather reports and directional signals.

A second network is required for two-way communication, and this must be provided by the transport companies.

The author discusses available and suitable wavelengths, the best types of antenna for airplanes, operation by telephone or telegraph key, power required on the airplanes and at the ground stations and shielding in the airplanec to prevent interference with reception.

The necessity of thorough shielding is emphasized and its lack is stated to be the one thing that is now delaying progress. The provision of such shielding is said to be the responsibility of both the engine manufacturer and the airplane builder.

RADIO is rapidly becoming as vital to the pilots and operators of transport airplanes as it has been for many years to the captains and owners of ships at sea. In fact, the fullest use of radio for communication and navigation purposes is so essential to the continued success of air transportation, not only from the standpoint of general operations but as a matter of public policy as well, that it probably will be only a matter of months before governmental requirements for the use of reliable radio by transport airplanes will be established, just as we now have radio requirements for ocean-going vessels. But marine radio has been in the process of perfection for almost 25 years, and its technical development and operating procedure have been evolved to fit the particular needs of the shipping industry.

An axiom of radio communication is that radio on mobile units is of little value without land stations with which they can directly or indirectly communicate, except in cases of immediate distress when rescue by some other mobile unit is possible. In marine work land stations have gradually been extended all over the world, using apparatus, wave-lengths and operating technique specifically adapted to their method of operation. Today the fullest benefit of reliable radio communication and navigation is always available to marine vessels except under rare circumstances.

Radio for aviation is comparatively new. It is true that two-way communication with airplanes in flight was established as long ago as before the World War, but its intensive application to commercial transportation is little more than a year old. In this short period it has been necessary to develop apparatus of a type quite different from any used before, to iron out all of the difficulties relative to its installation and performance in airplanes, to install a complete system of ground stations, to organize systems for the rapid collection of weather information of an entirely new sort, and to develop a new technique of radio operation and control. In 12 months aviation has had to go through 25 years of marine experience. I do not want to be misunderstood as implying that marine experience has not been of value in aviation, because shipping provided the initial stimulus for radio development in its early stages. However, the more recent research in telephone broadcasting and the amateur activities on short waves have had the most direct bearing on aviation-radio problems.

Stations Provided by Department of Commerce

The Airways Division of the Department of Commerce took the first step in providing ground stations for aeronautic use. About 40 stations have been installed or are being erected. They are dotted along the airways approximately 200 miles apart and extend across the whole Country from New York City to San Francisco and from Seattle to Key West. These stations use voice and have a carrier output of 2 kw., giving them a conservative day-range of 125 miles and a night range of approximately twice that distance.

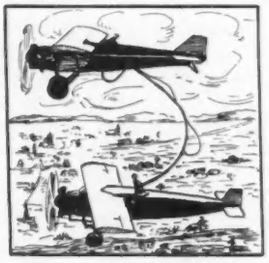
A band of wave-lengths between 800 and 1200 meters was set aside for aeronautical purposes by the international convention in 1927, and the Government stations are located within this portion of the frequency spectrum.

A new branch of the Weather Bureau has been built up to make hourly collection and forecasts of weather conditions, and the reports are then broadcast from the stations of the Airways Division. This service will soon be speeded up until the reports are gathered and broadcast every half hour. This service is of great value to the aviation industry. It means that any aviator, whether flying for sport or on scheduled transport business, can install a simple receiving set and, after eliminating ignition interference, receive the latest weather information almost anywhere in the Country. The pilot need not know code, for everything is sent out by voice, and the actual manipulation of the receiver is as simple as that of any receiving set in his home.

We have all heard a great deal about radio sets in automobiles lately. These have been designed strictly

[1] Radio engineer, Western Air Express, Los Angeles.

for entertainment purposes, as their tuning range has limited them to reception between 200 and 550 meters. Why not extend this tuning range to 1100 meters, so that they can pick up the airways weather-stations? The engineering problems involved, while complex, are by no means insolvable; in fact, at least one American company is now selling such a set in European markets, where there is a demand for a set that will not only pick up stations in the ordinary broadcast band but many of the long-wave broadcasting stations on the Continent as well.



The Airways Division has also installed a number of radio beacons for use in conjunction with the voice-broadcasting stations. I shall give only a very brief description of these because they have been fully described before. By means of a directional antenna at the transmitting station, a different combination of dots and dashes is sent out on either side of the airway. Exactly along the correct route, however, these code letters blend into a series of long dashes. A pilot listening to the signals can therefore tell when he is properly on the airway, or, if he is to one side or the other, which way he should turn to get on his course again. Every half hour the radio beacon is turned off and weather reports are broadcast by voice on the same wave length.

Two-Way Systems for Transport Companies

Thus we have a system of weather-report collection, a radio broadcasting system for disseminating the information and a method of navigation along the airways. For itinerant or sport flying this will probably suffice for some time to come, but the transport companies, flying almost 100,000 miles per day on schedule, need something more; they need reliable two-way communication with their pilots at all times. The position and progress of the airplanes must be followed continuously; special operating, landing, or weather instructions to or from the plane may be necessary at any moment; and, in case of emergencies or forced landings at out-of-the-way places, calls for assistance and reassurance as to the safety of the airplane and its cargo are vitally necessary.

The Department of Commerce stations obviously will not be able to carry this additinal load of communication and still perform their major function of broadcasting information and transmitting beacon signals to everyone impartially. This means that a second network of ground stations is necessary for the exclusive purpose of carrying on communication with individual planes while they are in flight. This latter problem is entirely a function of the transport companies. A number of difficult questions that had to be decided were: what wave-lengths to use, how far apart the ground stations should be spaced, what special requirements were imposed upon the apparatus that had to be developed, what modifications or changes on the planes were necessary to prepare them for the use of radio, and what measures of cooperation were necessary between the various transport companies, the Federal Radio Commission and the Department of Commerce to assure the most economical use of wave-lengths and apparatus and also properly to provide for future growth.

A few wave-lengths in the long-wave band which were still unused by the Department of Commerce were available for transport companies. The general feeling, however, was that the public interest would be best served by having the Department of Commerce make the fullest possible use of this band for the extension of its network of broadcasting stations over the entire Country. In any event not enough channels were open in this portion of the spectrum to serve more than a few of the transport companies. Other disadvantages in the use of long waves were that, although they had been successfully used in Europe for ground-to-plane and plane-to-ground work, they require very large antennas both at airports and on airplanes, the installation of which is expensive and makes flying conditions dangerous.

Fortunately the Federal Radio Commission had set aside a number of channels between 45 and 200 meters for aircraft work. The majority of the transport companies therefore turned to short waves. Assertions were made in advance that these waves were erratic, that communication could not be established on them over the necessary distances, and that suitable apparatus could not be developed. Fortunately, the first and second of these difficulties were overcome chiefly by solving the third; that is, erratic performance and lack of distance were removed when the right type of apparatus was properly installed and operated.

Requirements of Short-Wave System

Before a communication system could be developed on short waves, a number of problems had to be solved and three principal requirements had to be met. The first of these was that uninterrupted communication should be possible up to a distance of at least 100 miles at any time of the day or night and at any altitude. This requirement was imposed because it is not feasible to place ground stations closer together than the existing main landing-fields along the airways, which are about every 200 miles apart. The second was that a trailing-wire antenna was not permissible; and the third, that the system should be as nearly automatic and foolproof as it was possible to make it.

In meeting these requirements it was necessary that the following questions be decided:

(1) What wave-length between 45 and 200 meters should be chosen?

(2) What type of antenna should be installed on the airplane, and what effect, if any, would the choice of antenna have on the wave-length to be chosen?

(3) Should the system be operated by means of telephone or telegraph?

(4) What power would be required on the airplanes and at the ground stations to cover the distances required?

(5) What measures were necessary to eliminate ignition interference on the airplanes and to adapt the planes for the use of radio?

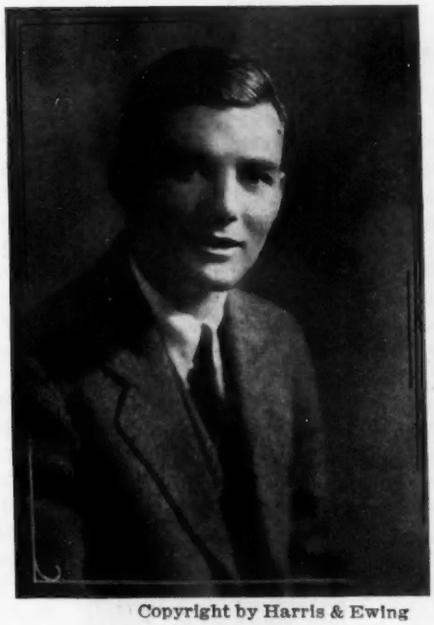
The general behavior of the wave-lengths between 45 and 200 meters was fairly well known for points on the ground, but little work had been done on these wave-lengths between aircraft and the ground over the distances which were now involved. Tests showed that, at any given distance from a ground station, better

signals were almost always obtained from airplanes flying at great altitudes than when they were flying low or had landed. The determining factor, therefore, was not whether good communication could be maintained at great altitudes but, rather, the possibility of an airplane landing anywhere within the desired radius and still being able to continue communication. It was also noted that some waves followed the contour of the ground better than others, but that the results were not uniform all over the Country. For this reason, each company had to make extensive flying tests to determine conditions over its own route.

"Skip" Effect of Short Waves

In general, however, continuous communication is possible in the daytime on wave-lengths above 45 meters. At wave-lengths below about 45 meters a "skip" effect is noticed; that is, a dead spot begins to make its appearance about 50 to 75 miles from the transmitter and extends outward for a limited distance in all directions. The shorter the wave-length is, the greater will be the distance before the signal reappears. At night the "skip" effect becomes noticeable at all wave-lengths below about 80 meters. This means that if a single channel is desired for both day and night work it should be chosen between 80 and 200 meters.

In daylight the weakening of signals in the band from 80 to 200 meters is severe over distances of 60 miles or more, and reliable communication beyond this distance is possible only under very favorable conditions. At night, however, relatively long distances can be covered and reliable communication has been maintained up to 1200 miles. The phenomenon of reduced range on these wave-lengths during daylight hours is exactly like that commonly noticed with broadcasting stations except that it is possibly more severe on the shorter waves. On wave-lengths from about 45 to 60 meters, very good daylight communication is possible for 150 miles or more, although at night the "skip" effect makes reception uncertain over short distances.



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HERBERT HOOVER, JR.

To obtain continuous communication, under normal operating conditions, for a distance of 150 miles in both daylight and darkness, it seems to be necessary to make a shift in wave-length from one band to the other twice during each 24 hr., once in the morning and again in the evening. This would be a simple matter if ground stations alone were involved, but greater difficulty is presented in the case of airplanes in flight. Either the plane must be landed at an airport and a new transmitter and receiver installed to send and receive on the new wave-length, or switching devices for making the desired change during normal flight must be incorporated. Both methods have their complications.

The trailing-wire antenna on aircraft has long been regarded as dangerous, and its replacement with some permanent arrangement of wires strung between the fuselage and wings is very desirable. This obviates the necessity of reeling in and out whenever the airplane lands or takes off, and also has the advantage that communication is possible when the ship is flying very low or is actually at rest on the ground. Another advantage is that a final over-all test of the apparatus and antenna is possible just before the plane takes off.

Fixed Antennas on Airplanes

Two arrangements of fixed antennas appear to be possible. A pair of wires can be strung from the fuselage out to each wing-tip and tuned to radiate as a horizontal doublet. This sends out a horizontally polarized wave. The alternative is to keep the same arrangement of wire but use the frame of the airplane as a counterpoise. A larger vertical component is obtained in this way. Airplanes of different types and makes have given widely different results with each scheme, and determining which is the more suitable for any particular case has been a matter of trial.

In either arrangement the fundamental wave-length of the antenna is determined by the wing-spread of the craft. To obtain satisfactory output efficiency, the operating wave-length should be kept down as nearly as possible to the fundamental of the antenna. The fundamental on multimotored planes having wing-spreads of 70 to 100 ft. is from 45 to 80 meters, which makes possible fairly efficient radiation on both the day and night channels. On small planes, such as the single-engined mail types having wing-spreads of 50 ft. or less, the antenna has a fundamental of 40 meters or less. Most of the loss in antenna efficiency on the smaller planes can be overcome by increasing the power, but in any case, whether for small or large airplanes, the upper limit of useful wave-lengths seems to be approximately 100 meters when small fixed antennas are used.

The final choice of a particular channel or pair of channels is therefore restricted on the low side by the point where the "skip" effect begins to interfere with regular operation, and on the high side by the rapid loss of efficiency as the wave-length is increased above the fundamental of the fixed antenna. Under these practical restrictions, the most desirable channels appear to lie between 45 and 100 meters.

Available Wave-Length Channels

To conserve the short-wave channels to the utmost, the Federal Radio Commission and the Department of Commerce, in cooperation with all of the air-transport operators, have worked out a scheme of frequency allocation. The companies have been divided into four groups, and all of the ground stations and airplanes of the companies in each group will use the same channels. The basis for forming the groups was to select a trunk airway as the key member of each group and assign to it all of the smaller feeder routes that could be con-

veniently added. All of the members in each group will share the operation of the ground stations at places where they join and operate the stations as a single unit. Eventually, four chains of ground stations will extend across the Country, although only two are now in operation. The wave-lengths of the several chains were spaced far enough apart so that interference should not occur at places where they overlap or cross, and enough channels were set aside so that additional chains might be formed later if congestion makes this necessary.

To provide two-way communication for itinerant or taxi planes, or for transport-company airplanes that are temporarily off their usual routes, the Federal Radio Commission set aside the wave-length of 97 meters (3106 kilocycles) and designated it as the National Calling Frequency. All ground stations are required to keep watch on this channel and to communicate with any airplane that calls them. The Commission also agreed to assign the wave-length of 1060 meters to any airport that requests it, so that itinerant or taxi planes would need only the usual long-wave receiver to carry on two-way contact with the ground and to receive landing instructions or local weather reports. To avoid interference between various airports using this wave, the power was restricted to 10 watts and the range to 25 miles.

Question of Telephone or Telegraph Operation

The question of whether telephone or telegraph should be employed was left for the individual transport companies to decide. On systems flying single-engine mail-planes with but a single pilot, the telephone is the logical choice. On the whole, pilots have not been found to make satisfactory radio-telegraph operators. Transport lines flying multimotored equipment, however, can use either telephone or telegraph, for there is room enough to carry a radio operator if necessary. Very satisfactory telephone communication is possible on domestic transport systems where the ground stations can be spaced about every 200 miles, and it is therefore only a question of weight, expense and operating convenience as to which method is employed. Radio telephony requires more powerful ground and airplane transmitters than does telegraphing, and the equipment is heavier and more expensive. On the other hand, telephonic communication is quicker and more reassuring to the pilot, and the weight and expense of an operator are avoided. The Colonial Airways and the Curtiss Flying Service are using the telegraph system, while the Boeing Air Transport, the Transcontinental Air Transport, and the Western Air Express are using the telephone. All are operating satisfactorily.

The telegraph undoubtedly is the most desirable method of communication for transport systems operating over water or with particularly long jumps between bases. The additional range of the telegraph may be vitally necessary in these cases, and the operator can obtain radio bearings and communicate with marine vessels if the need arises. The Pan-American Airways has obtained exceptionally reliable results with such a system.

For telegraph work, 250-watts output on the ground and 15 watts on the airplane seem to be satisfactory. For telephone communication, about 400 watts of carrier output, which when fully modulated gives 1600-watts peak-power output on voice, is necessary on the ground. Fifty watts of carrier output, giving 200-watts peak-power output on voice, fulfills the requirements on the plane.

The development of apparatus has taken considerable time, because the requirements imposed a completely new set of standards in regard to weight, performance and reliability. Pending the time when such apparatus was available in commercial quantities, the transport operators developed equipment for experimental or temporary use, and much valuable experience was gained in this way. However, equipment is now available that fulfills the needs of commercial air transportation.

Sources of Airplane Transmission-Power

Three methods of obtaining power on the airplane are generally accepted. The first is to use a double-voltage generator driven directly by the engine. This is by far the most efficient but has the great disadvantage that if the engine fails the radio is automatically out of commission. The second method is to use a dynamotor driven by the ship's lighting battery. This permits use of the radio for a limited time after the engine has failed but is heavier than an engine-driven generator and is only about 50 per cent as efficient. The biggest disadvantage, however, is that the running load placed on the battery system of the plane is about 70 amp. and the starting load is several times that figure. Under frequent use, the life of a light 12-volt 65-amp-hr. battery is problematical. The third method is by means of a wind-driven generator. This has the advantage that it is independent of the engine and battery system and will operate as long as the plane has an air-speed of 60 m.p.h. or more. The drawbacks are that the radio is inoperative when the plane is on the ground, that its over-all efficiency is less and its effective weight is greater than is the case with either of the other systems.

The choice of any of these systems is a matter of compromise at best and deserves further investigation. One possible solution is the use of a wind-driven generator having a sufficiently heavy low-voltage winding so that in case of a landing the propeller may be removed and the machine temporarily operated as a dynamotor from the battery of the airplane. Another possibility, particularly on large planes, is a generator driven by a small gasoline engine that can also be operated as a dynamotor in case of necessity.

Summarizing this far, we can expect to see all of the major transport lines of the Country thoroughly equipped with two-way radio in the very near future, if they are not so operating at present. Probably only a short time will elapse before this will be required by law, in much the same way that ocean-going vessels are now rigidly regulated in this regard.

Development work is rapidly being pushed on additional radio devices to aid in the navigation of airplanes. Many possibilities present themselves in this field. Long and short-wave beams are being investigated, and many methods of using directional receiving equipment on the airplanes and at airports are avail-

able. A device that is vitally needed is an altimeter that will give the true distance above the ground. Undoubtedly this will come eventually, although it is still too early to say whether it will operate by radio or by some other means.

Effective Shielding of Major Importance

I have left the subject of shielding until last because it is the most important. The following discussion is chiefly concerned with the practical viewpoint of the transport operator. I believe that the airplane and engine manufacturers do not realize how serious the situation is and how much depends upon their willingness to cooperate.

First, to emphasize the importance of shielding: Each spark-plug in the engine is a miniature radio-transmitting station. The ignition wires, magneto, low-tension wires and their associated parts form an antenna system. Every time a spark occurs across any of the plugs, a radio impulse is sent into this antenna and a corresponding signal is radiated out into space. As the wiring of the airplane is not tuned to any definite frequency, the spark interference can be received on virtually any wave-length from zero to infinity. Furthermore, spark transmitters are famous for the interference they create, even when working into sharply tuned antennas.

If it is imagined, therefore, that a highly sensitive receiver on the plane is trying to pick up a feeble signal from a station that is perhaps 150 miles away, and only 10 ft. away are located from 18 to 72 strong spark-transmitters feeding into an antenna which is radiating on all wave-lengths, a fair idea of what ignition interference means can be visualized. The interference thus created is much worse on waves below 200 or 300 meters than it is on longer waves, although it is sufficiently strong on any wave-length to seriously interfere with reception.

A few instances will show just how serious this problem is. Virtually no interference is noticeable on a well-shielded airplane, and waves from a 400-watt short-wave telephone transmitter can be received at a distance of 200 miles or more. If no shielding has been installed, reception is impossible at more than 20 or 30 miles. If a slipshod or inefficient installation has been made, or if only a few inches of shielding is left off of any of the wires leading to the magneto, the zone of communication will be cut down to about 50 miles. It is interesting to note that, even if the spark-plugs, high-tension wiring and magnetos are carefully shielded and the battery wiring on the airplane is left unshielded, the interference is so strong that it is hard to tell that any improvement has been made. Therefore, the problem is one not only for the engine manufacturers, but just as vitally affects the builders of airplanes.

Responsibility of Engine and Plane Builders

Only one solution is possible; all of the spark-plugs, the high-tension and low-tension wiring, the magnetos, booster magnetos or coils, switches, starters, generators, batteries, and all of their associated parts must be continuously enclosed in a grounded metallic shield. The chief difficulty, in practice, arises in making an installation that will stand up under the continuous grind of transport service.

Shielding is the determining factor in whether or not radio is to give us safer flying. The responsibility of making all new airplanes ready for radio is squarely up to the manufacturers of airplanes and engines. The transport operators provide the experimental laboratories in this development and are glad to give the benefit of their experience to the manufacturers of their equipment or to any others who may be interested. Unfortunately, none of the engines available today will give reliable transport radio service with the shielding equipment which comes with them from the factories. Furthermore, no adequate engine shielding except that fabricated by a few of the larger transport companies for their own use is available to the industry. In the face of this fact, the industry as a whole is soon to be required by law to have reliable radio communication between airplanes and the ground.

Up to the present time shielding has been an afterthought in the design and construction of airplanes. No doubt exists that a general reconsideration of the problem should be undertaken so that shielding shall be made an integral part of the final product. An opportunity is presented to improve the entire electrical installation in airplanes and to make them more reliable than they have ever been before. As an example, the wiring can be run in light aluminum conduits fastened permanently into the fuselage in much the same way that houses usually are wired. The conductors will thus be protected from moisture, gasoline and oil, and in the event of a short circuit the danger of fire will be greatly reduced. Furthermore, inspection and replacement of the wires will be possible without tearing the fuselage apart, and, in the event that additional circuits are later required, they can be added quickly and conveniently. This method of construction is particularly desirable for protecting wires running to and from the engine, in which case flexible aluminum BX has been used to avoid breakage resulting from vibration.

Leads to Switches Should Be Short

Wiring can be dispensed with and the electrical reliability of the engine improved by an arrangement whereby the starter-engaging switch also puts the booster coil in operation. This makes possible the mounting of the coil directly on the engine and keeping all the leads short and direct. Another possibility is to design the magneto-grounding switches as an integral part of the magneto and close them by retarding the spark control to the extreme position. The latter two changes are particularly desirable from a radio standpoint, because it has been found that a large amount of the ignition interference is carried back into the wiring of the airplane by the leads from the magnetos to the grounding switches and the booster coil, even though they apparently may be well shielded.

Another highly important factor is the sheath enclosing the high-tension wires from the magnetos to the spark-plugs. The universal experience of all transport operators has been that no kind of braided wire-covering has proved fully satisfatory. Deterioration

(*Concluded on p.* 345)

The Provision of Radio Facilities for Aircraft Communication

By E. L. Nelson[1] and F. M. Ryan[2]

St. Louis Aeronautic Meeting Paper — *Illustrated with* Photographs and Drawings

THIS subject is discussed by the authors from the viewpoint of the radio engineer. The periods of fundamental study and development of apparatus are stated to be drawing to a close, and we are said to be well advanced toward the third and last period—that of general application to commercial flying.

The discussion of radio-communication outfits is based on aircraft equipment recently developed by the Bell Telephone Laboratories for receiving weather reports and beacon signals and for two-way telephonic communication between the airplane and ground stations.

Units of different types of apparatus for use in small mail-planes and in large transports are illustrated and described, together with tabular data of sizes and weights of individual units of both general types of outfit.

Information regarding the requirements of shielding, bonding and installation is given, and the airplane factory is stated to be the place where provisions for radio installation can best be made. If suitable provisions have been made therefor, the installation of two-way radio equipment is said to be simple and inexpensive.

A number of the larger air-transport organizations have made noteworthy progress toward providing suitable radio systems and the Department of Commerce is giving much assistance in the way of radio aids to air navigation, but a great deal of work remains to be done by the industry as a whole and numerous problems will require solution. New requirements will be encountered as the number and size of airplanes increase, but continuing radio studies promise that the development of aircraft radio communication will keep abreast of the development of airplanes.

THAT the highest degree of reliability and safety in air transportation can be achieved only when adequate radio facilities are available is now generally recognized by the entire aircraft industry. A number of the larger air-transport organizations have already made noteworthy progress toward the provision of suitable radio systems, and the Department of Commerce is doing much to assist them by providing radio aids to air navigation. Considering the industry as a whole, however, a vast amount of work remains to be done and numerous problems will require solution. A discussion of the subject from the viewpoint of the radio engineer may therefore be of considerable interest.

From this point of view, the provision of radio facilities involves three distinct periods of development:

(1) Fundamental studies
(2) Apparatus development
(3) Application

The first two of these periods are drawing to a close. Considerable quantitative information is now available

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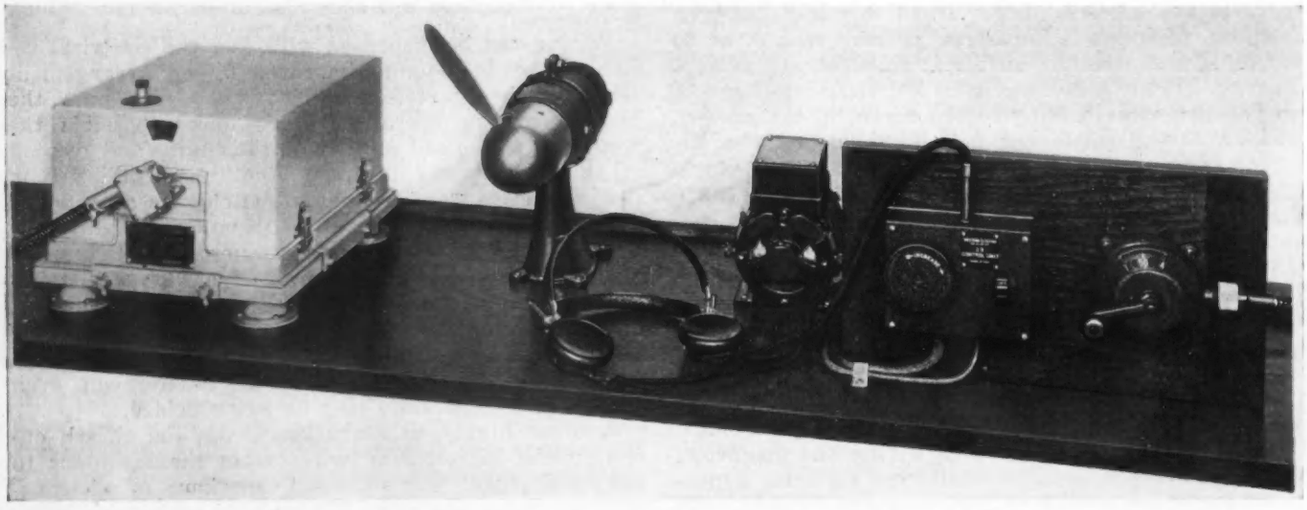

Fig. 1—Western Electric Co. Low-Frequency Aircraft Radio-Receiving Outfit for Weather Reports and Beacon Signals

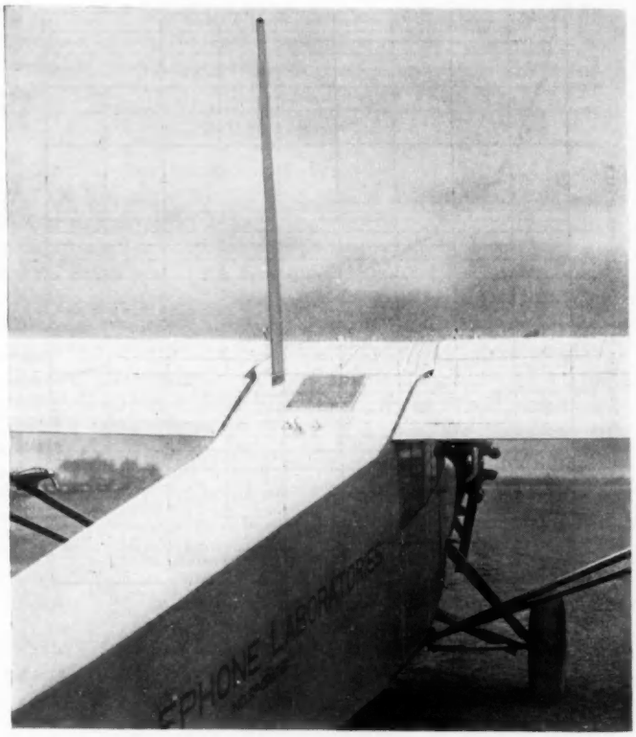

FIG. 2—TYPICAL INSTALLATION OF SELF-SUPPORTING STREAMLINED VERTICAL ANTENNA ON AN AIRPLANE

concerning the strength of the signals that can be obtained with a given amount of power at various distances, altitudes and frequencies[3]. On the basis of this fundamental information, a plan has been worked out for equipping the airways of the Country, which involves ground stations at approximately 200-mile intervals. Several manufacturers are offering apparatus for both the airplane and the ground stations of this network. Aircraft receiving apparatus is also available for the reception of the Government weather and beacon signals. We are, therefore, well advanced toward the third period in the development, that of general application to commercial flying. This period is in many ways of the greatest importance, as it directly concerns not only the communication engineer and the radio manufacturer but also the airplane manufacturer, the engine manufacturer and the airplane operator. Close cooperation among these groups can do much to accelerate the general introduction of radio on the airlines of America.

For obvious reasons the discussion which follows is based on the Western Electric aircraft radio-equipments recently developed by the Bell Telephone Laboratories for both the weather and beacon and two-way radio services. Consideration of the installation of these equipments in commercial planes will serve to direct attention to the outstanding applications problems which are of prime importance to operators of airplanes and manufacturers of engines and planes.

Weather and Beacon Receiving Outfit

The Department of Commerce stations transmit weather information by radio telephone at frequent intervals from many points on the principal airways of the Country. At some points this transmission is supplemented by directional beacon service of the aural type. Both of these Government aids to air navigation are operated at frequencies between 285 and 350 kilocycles.

The low-frequency weather and beacon receiving outfit shown in Fig. 1 illustrates the type of apparatus required for the utilization of these services. Table 1 gives approximate space and weight information covering each unit comprising this outfit. The radio receiver, which covers the range of 250 to 500 kilocycles, is arranged for complete remote control and is operated by the pilot. It is a five-tube set having three stages of tuned radio-frequency amplification, a detector and one stage of audio-frequency amplification. Heater-type tubes are employed throughout and, with the exception of the audio amplifier, are of the screen-grid type.

The receiver requires for its operation 1.6 amp. of direct current at a voltage of approximately 12, and 25 milliamperes of direct current at a voltage of 200. In planes having standard 12-volt storage-battery installations with charging generators, the low-voltage supply is obtained directly from the battery, and a small dynamotor operated from the battery furnishes the 200-volt supply. In planes not so equipped, a small constant-speed wind-driven generator is used to supply both voltages. Fig. 1 shows both types of power-supply equipment.

Remote volume control is accomplished by locating the voltage divider, which supplies the shield-grid potential of the radio-frequency amplifier, in the 2-B control unit, which may be installed within reach of the pilot. Remote tuning is accomplished by the use of a flexible shaft which turns at a speed 264 times that of the variable-condenser shaft. The receiver may be located as much as 35 to 40 ft. from the 1-A control unit and the tuning accomplished with very little backlash.

The receiver, while necessarily of light and compact construction, is extremely rugged, a cast-aluminum bedplate forming the base for the support of all the apparatus units. A welded sheet-aluminum top cover protects the apparatus from dirt and moisture. A cushioned mounting base is provided which is permanently

TABLE 1—LOW-FREQUENCY WEATHER AND BEACON RECEIVING-OUTFIT

Unit	Approximate Size, In.	Approximate Weight, Lb.	Oz.
9-A Radio Receiver	9⅜ x 6 x 10	16	0
1-A Mounting, for 9-A Radio Receiver	2 x 11 x 11	2	6
1-A Control Unit (mechanical tuning control)	1¾ x 3¾ x 3⅜	1	0
2-B Control Unit (contains volume control, output jack and control switches)	2¼ x 5 x 4	1	7
1011-A Headset			13
KS-6589 Dynamotor (plate power supply for receiver)	4 x 6¼ x 6½	7	10
KS-6662 Flexible Shaft and Cable (mechanical drive to receiver), 10 ft.		1	13
Cables		4	
Antenna		4	
	Total Weight	39±	2

[3] See *Journal of the American Institute of Electrical Engineers*, January, 1930, p. 50.

installed in the airplane. The receiver may be readily removed from this mounting, as a single plug provides for all power supply and output leads, and the flexible shaft is quickly detachable.

A general type of self-supporting streamlined mast antenna, which is being widely used with this type of receiver, is illustrated by Fig. 2. The mast shown is of hollow wood construction having an internal conductor and extends approximately 7 ft. above the fuselage of the plane.

Fig. 3 is a phantom view of a mail plane showing, in a diagrammatic manner, the location of the various units of a weather and beacon receiving outfit employing a dynamotor for plate power supply. As will be noted, only the two control units are located in the cockpit. The dynamotor is located near the storage battery. The radio receiver is installed aft of the cockpit near the mast antenna, which is located as far from the engine as possible so as to minimize ignition interference.

Shielding

The normal range of this equipment is from 125 to 200 miles when receiving weather reports from the 2-kw. Government stations. An examination of Fig. 4 will show that signals having an electrical field strength of less than 25 microvolts per meter must be successfully received if maximum range is to be attained. This necessitates virtually complete elimination of interference from the airplane-engine ignition system and other electrical equipment. Electrical shielding of the ignition system and other electric circuits in the plane is the practical solution of this problem. Unless the shielding is very thoroughly done, interference is certain to be experienced and the range over which signals can be satisfactorily received greatly reduced.

Complete shielding of the airplane engine requires, not only that the high-tension leads from the magnetos be totally enclosed by a good electrical conductor grounded to the engine at frequent intervals, but also that the spark-plugs be completely shielded. Moreover, the magnetos and booster magneto and all control switches and low-tension ignition wiring must be similarly shielded. The electrical problem of providing shielding is very simple but mechanical difficulties are numerous. Recent cooperative attacks on the problem by Government departments and radio, accessory and engine manufacturers have resulted in considerable progress, and shielded ignition systems having electrical and mechanical characteristics equal, if not superior, to the unshielded systems are being made commercially available. Fig. 5 shows such a shielded system installed on a radial engine. This "harness" provides, in addition to electrical shielding, protection from mechanical injury, oil and moisture.

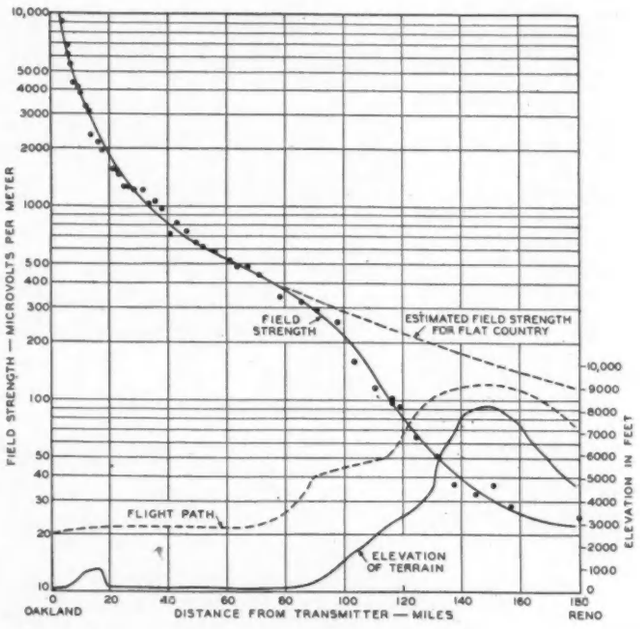

FIG. 4—TYPICAL CURVE OF STRENGTH OF SIGNALS RECEIVED IN AN AIRPLANE FROM AIRWAY WEATHER-REPORT TRANSMITTING STATIONS

Much unnecessary expense can be avoided by equipping airplane engines with properly designed shielded ignition systems at the time of manufacture. Moreover, the engine manufacturer is responsible for the performance of his product and should therefore assume responsibility for the shielding, which, if improperly done, may result in engine failures. This is particularly true of the spark-plugs.

The airplane manufacturer likewise may greatly simplify the equipment of airplanes with radio and lessen the expense of radio installation by carrying out certain work at the time the plane is built. All wiring from the charging generator to the storage battery, to switches and to all lights should be thoroughly shielded at the time of installation and the shield grounded to the fuselage frame at frequent intervals.

The airplane designer may also contribute greatly to the satisfactoriness of the radio installation by giving adequate consideration to the space and weight of the apparatus to be accommodated. Particularly in the case of the control units, it is frequently difficult to find suitable space for installation in present-day planes. Much could be done to avoid

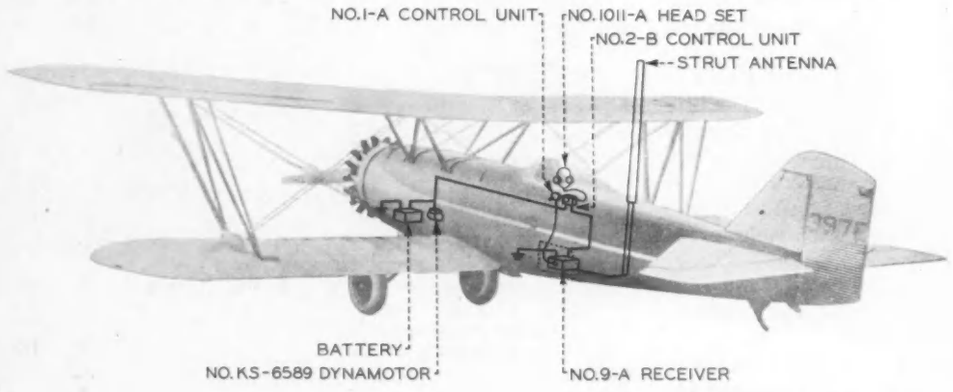

FIG. 3—PHANTOM VIEW SHOWING ARRANGEMENT OF LOW-FREQUENCY RECEIVING OUTFIT IN A MAIL PLANE

this difficulty were the designer to give the same consideration to radio instruments that he now gives to other aids to navigation, such as altimeters and compasses.

Bonding

It is also necessary to electrically bond all the metal parts of the plane to form a single conducting system. Of particular importance is the bonding of moving parts which may come into intermittent contact during flight. Such contacts produce violent disturbances in sensitive receiving apparatus. The bonding, like the shielding, must be done in a workmanlike and permanent manner. All connections should be made electrically and mechanically perfect without the use of solder and then soldered to ensure that they will not deteriorate with time. Particular attention should be given to the design of the flexible bonds necessary to ground the control wires, rudder, ailerons, and so forth. Obviously, this work should be done at the airplane factory at the time the plane is built.

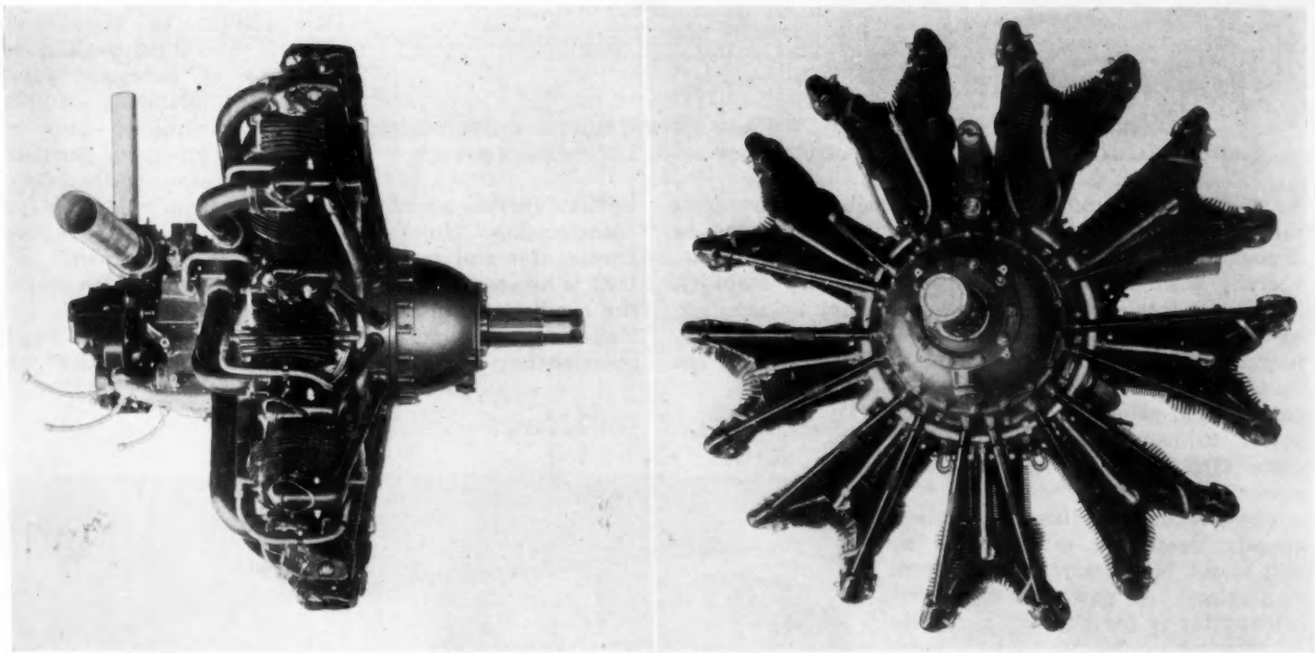

FIG. 5—BREEZE SHIELDED-IGNITION HARNESS INSTALLED ON A PRATT & WHITNEY HORNET ENGINE

Installation of Receivers

The installation of the radio receiving outfit in a plane is so simple that it can be done at almost any field shop if the plane has already been properly shielded and bonded. A much more satisfactory installation can be had, however, if suitable mounting brackets have been provided in the plane at the factory at the time of manufacture. The factory is, of course, a very satisfactory place to complete the installation. The design and installation of a suitable mast antenna in the field is often difficult, and every plane should be provided with adequate supports and mounting fixtures for such a mast at the time it is built.

While a weather and beacon receiving outfit is a very valuable aid in safely maintaining the scheduled flights of a passenger or mail plane, the fullest assistance from radio is had only when two-way communication with ground terminals is available. The great speed of airplanes and their dependence on weather conditions make imperative that this communication be very rapid and preferably directly between the pilot and the air-transport dispatcher located on the ground. Radio telephony provides this rapid and direct contact, without the necessity of transporting a trained operator.

The Two-Way System

The two-way radio telephone equipment for use in both transport and mail planes is shown in Fig. 6. This is a phantom drawing showing diagrammatically one arrangement of this equipment in a transport plane. It is arranged to be controlled by the co-pilot, and the circuit provides for talking from any one of four positions. The controls in the cockpit of the plane are shown in Fig. 7. This view also shows how the reel for a trailing-wire antenna can be installed.

The equipment can be operated in any of the aircraft bands in the frequency range from 1500 to 6000 kilocycles. A trailing-wire antenna provides the most satisfactory transmission. However, at frequencies above 3000 kilocycles, suitably insulated masts similar to the one shown in Fig. 2, but provided with a small umbrella-antenna consisting of four short guy wires, have been successfully employed. A diagram of a two-way mail-plane installation using this type of antenna for both transmitting and receiving, and employing a dynamotor to supply plate power to the transmitter, is shown in Fig. 8. This installation includes a low-frequency receiver for weather and beacon reception and the two receivers are operated from the same antenna. Table 2 gives the approximate size and weight of each piece of apparatus used in the installation.

The principal apparatus elements of the plane equipment are the radio transmitter and the radio receivers. The transmitter, shown in Figs. 9 and 10, is of 50-

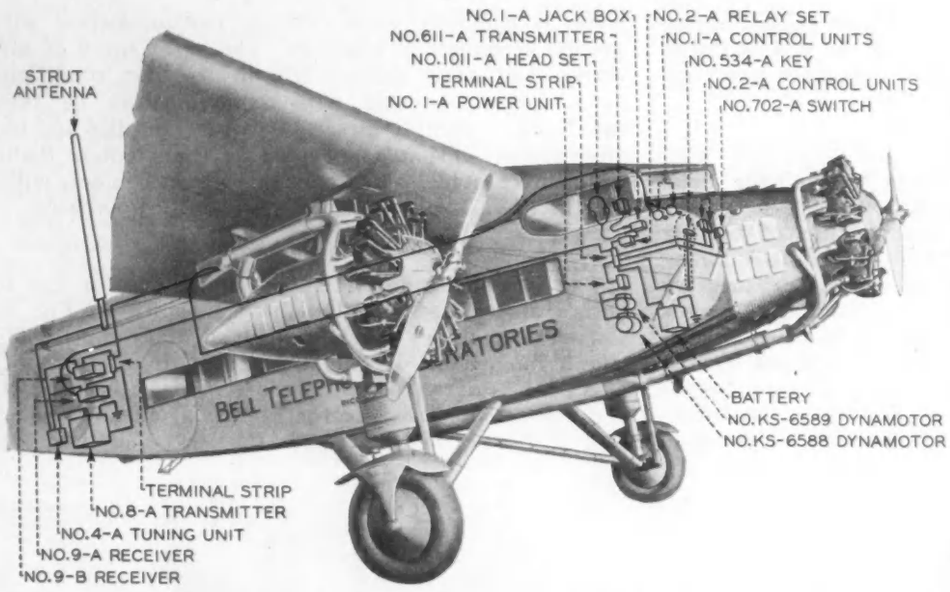

FIG. 6—ARRANGEMENT OF HIGH-FREQUENCY TWO-WAY RADIO-TELEPHONE EQUIPMENT, SHOWN DIAGRAMMATICALLY ON A PHANTOM VIEW OF A TRANSPORT AIRPLANE

watt carrier output power and capable of complete modulation. The oscillator frequency is controlled by a quartz crystal held at a temperature of 55 deg. cent., thereby assuring a high order of frequency stability. There is a total of six vacuum tubes in the transmitter, an oscillator, a frequency doubler, a radio-frequency power amplifier and three audio amplifier tubes. The three audio tubes are connected in parallel and provide adequate speech power to completely modulate the plate circuit supply to the radio power amplifier.

The transmitter, like the receiver already described, is arranged so that it can be quickly removed from an airplane. All power supply to the transmitter is fed through a readily removable plug provided with a locking device. The speech input and the control circuits for starting and stopping the oscillator are connected to the transmitter through a three-conductor telephone plug. The transmitter is ordinarily removed from the plane for all testing and servicing. It is not necessary that it be accessible during flight.

The high-frequency airplane receiver employed for two-way communication is shown in Fig. 11. This receiver is of very similar electrical and mechanical design to the low-frequency weather and beacon receiver already described. Identical remote-control units are employed for the two receivers. One dynamotor is used to supply plate power to the two receivers when both are installed. Their output circuits may be paralleled, thereby allowing the pilot to receive calls on the two-way system while listening to beacon signals.

Convenient operation of the equipment is had by the use of a three-position master switch which serves to control the power supply for the radio receivers and transmitter. In the first position, everything is "off," in the second position the filaments of the radio receivers and the dynamotor furnishing plate supply to the receivers are energized. In this position, which is normal while in flight, the heater circuit of the quartz-crystal chamber of the radio transmitter is also energized. The third position of this switch serves to energize the filaments of the radio transmitter and to start the dynamotor furnishing plate power to the transmitter. In this position, everything is in readiness for transmission. However, no oscillations occur in the transmitter and reception is possible. To transmit, all that is necessary is to press a push-button which starts the oscillations in the radio transmitter. In some installations this push-button is located on the hand microphone; in others it is located on the "stick" so

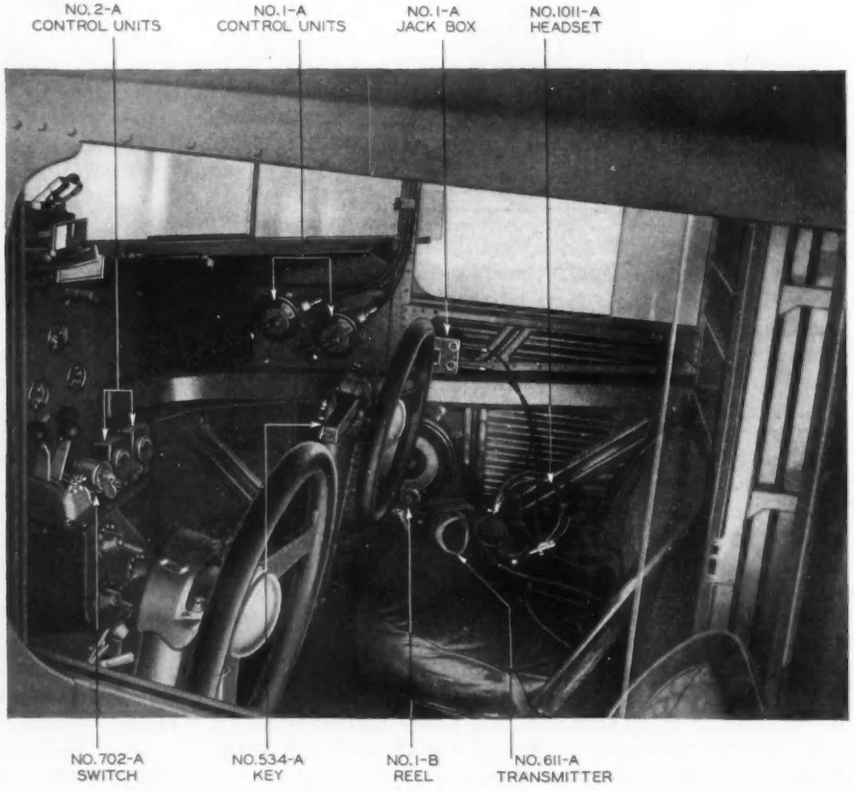

FIG. 7—ARRANGEMENT OF CONTROLS FOR WESTERN ELECTRIC CO. TWO-WAY EQUIPMENT IN COCKPIT OF A TRANSPORT AIRPLANE

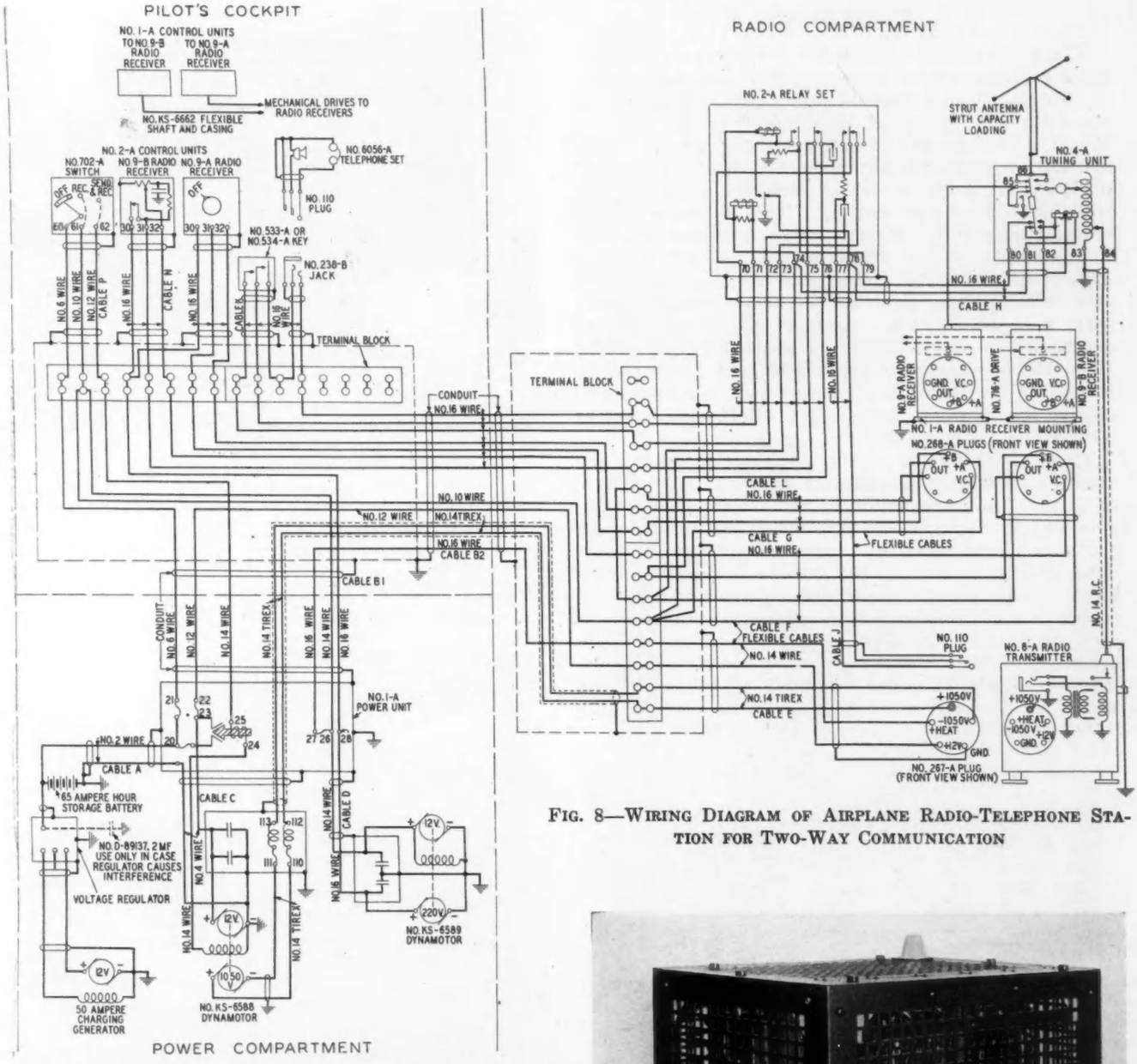

FIG. 8—WIRING DIAGRAM OF AIRPLANE RADIO-TELEPHONE STATION FOR TWO-WAY COMMUNICATION

that the pilot can operate it without moving his hand. During a conversation, this button is pressed while talking and released while listening. Relays perform all of the necessary switching functions.

In cabin planes, hand microphones of special design arranged to exclude outside noises are employed. For use by mail-plane pilots, a special helmet type of telephone set, illustrated in Fig. 12, is available in which the microphone is supported by adjustable rods. It is so arranged that the instrument may be dropped below the chin or turned up over the head when not in use. This telephone set is equipped with a small phonette type of receiver originally designed for the hard of hearing. These receivers weigh less than an ounce and are used in connection with small ear molds made to fit the pilot's ears.

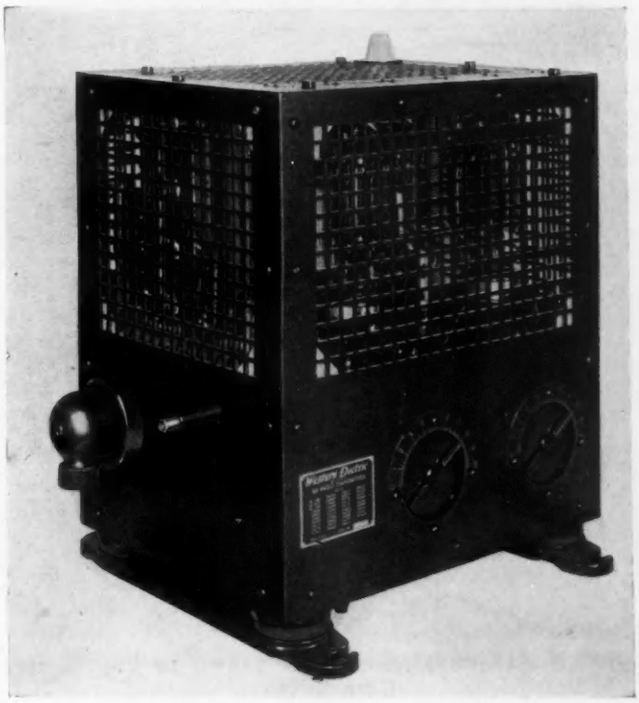

FIG. 9—HIGH-FREQUENCY 50-WATT RADIO-TELEPHONE TRANSMITTER FOR TWO-WAY COMMUNICATION

Power Supply

The airplane radio transmitter requires for its operation a direct-current plate supply of 400 milliamperes at 1050 volts and a filament supply of about 15 amp. at about 12 volts. A typical power supply is that shown in Fig. 8, which consists of a 12-to-15-volt, 50-amp., automatically regulated generator gear connected to the airplane engine, across which is connected a six-cell, nonspillable lead storage-battery. The filaments of the transmitter are fed directly from this generator-battery combination and the plate supply obtained from a dynamotor operating from this same supply. The smaller dynamotor furnishes the 200-volt supply necessary for the receiver plate-circuits. Double-voltage engine-driven and wind-driven generators, furnishing 12 to 15 volts for battery charging and 1050 volts directly for the transmitter plate-circuit are also available. Fig. 13 shows these three alternative types of power-supply apparatus.

The standardization of the generator mounting and drive on radial airplane engines has done a great deal to further the introduction of radio equipment in airplanes by providing a means of obtaining the necessary electrical power. The installation of a two-way equipment usually necessitates the use of a generator having larger dimensions than the one supplied as standard equipment. Frequently the design of the airplane is such that a tubular member of the engine mount, the exhaust manifold or other auxiliary engine-equipment interferes with the larger generator. Airplane designs should be reviewed and ample clearance provided for the largest charging and double-voltage generators.

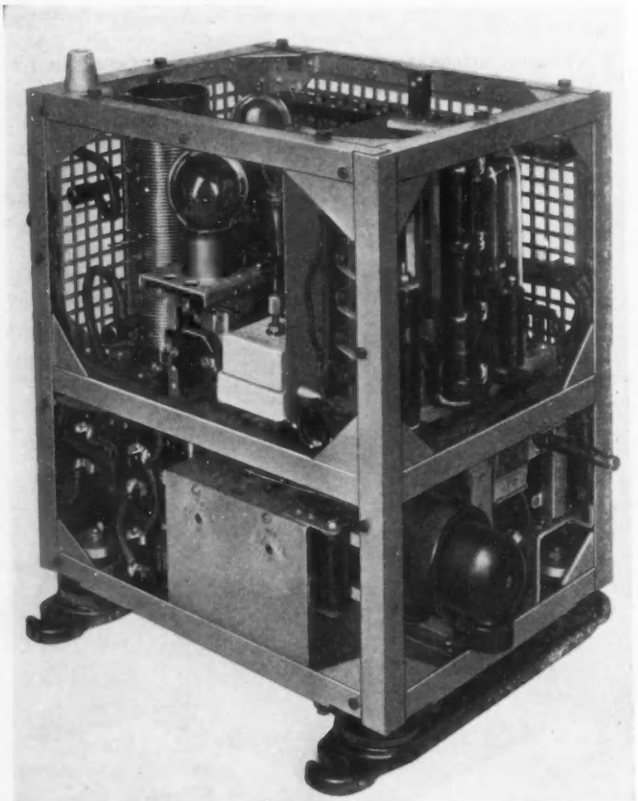

FIG. 10—SAME TRANSMITTER AS SHOWN IN FIG. 9, WITH BACK REMOVED

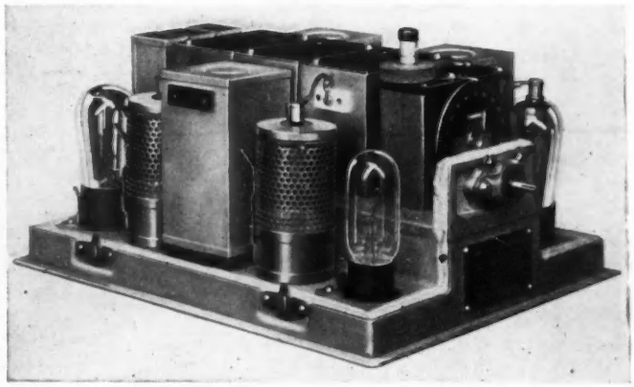

FIG. 11 — HIGH-FREQUENCY REMOTE-CONTROLLED RADIO-RECEIVER FOR TWO-WAY COMMUNICATION, COVER REMOVED

TABLE 2—AIRPLANE RADIO-TELEPHONE EQUIPMENT FOR TWO-WAY COMMUNICATION AND WEATHER AND BEACON RECEPTION

Unit	Approximate Size, In.	Approximate Weight, Lb.	Oz.
8-A Radio Transmitter	13 5/16 x 10 5/16 x 16	32	8±8
9-A Radio Receiver, low frequency	9 3/8 x 6 x 10	16	0
9-B Radio Receiver, high frequency	9 3/8 x 6 x 10	15	10
4-A Tuning Unit (contains antenna loading coil, antenna switching relay and meter)	8 5/8 x 8 5/8 x 6	5	8
2-A Relay Set (unit contains push-button-operated relays, which control transmitting and receiving circuits)	1 1/2 x 3 7/8 x 4 1/2	2	1
533-A Key (press-to-talk key mounted on control stick)	1 x 1 x 3		1
238-B Jack, for 6056-A telephone set	3/4 x 3/4 x 3		1
6056-A Telephone Set (includes transmitter and receiver		1	8
2-A Control Unit (volume control for 9-A and 9-B Radio Receivers; two required)	2 1/8 x 2 1/2 x 4		12
702-A Switch (three-position switch; "off," "radio receive," "radio transmit" positions)	2 3/4 x 2 3/4 x 2		8
1-A Power Unit (contains dynamotor starting relay and fuses)	3 x 4 5/8 x 7 3/4	3	8
KS-6662 Flexible Shaft and Cable (mechanical drive to receiver; two required), 10 ft.		1	13
KS-6588 Dynamotor (transmitting dynamotor and filter)	11 1/2 x 6 x 12	30	10
KS-6589 Dynamotor (receiving dynamotor and filter)	4 x 6 1/4 x 6 1/2	7	10
1-A Control Unit (mechanical tuning control; two required)	1 3/4 x 3 3/4 x 3 3/8	1	0
1-A Mounting, for 9-A and 9-B Radio Receivers; two required)	2 x 11 x 11	2	6
Terminal Blocks and Covers		2	
Cables		15	
Antenna		4	
	Total Weight	149±	3

FIG. 12—AIR-MAIL PILOT'S SPECIAL TELEPHONE SET

The dynamotor scheme of plate power-supply is probably the most satisfactory at the present time, as it provides for operation of the radio transmitter from the storage battery for short periods, thereby permitting of convenient testing on the ground and making possible communication after engine failure or on the ground in case of a forced landing. It does, however, sometimes place an overload on an already heavily

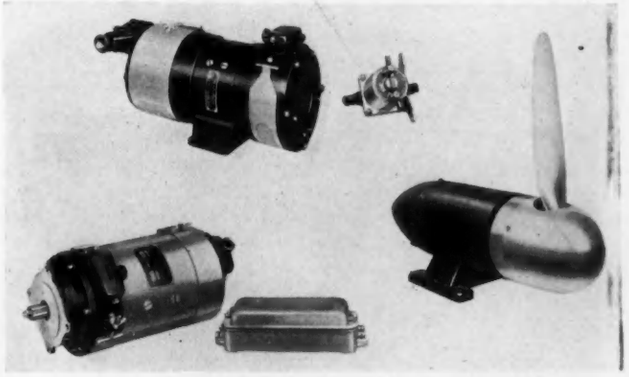

FIG. 13—ALTERNATIVE TYPES OF POWER-SUPPLY EQUIPMENT FOR TWO-WAY SYSTEM

The View Shows a Dynamotor, a Wind-Driven Generator and an Engine-Driven Double-Voltage Generator

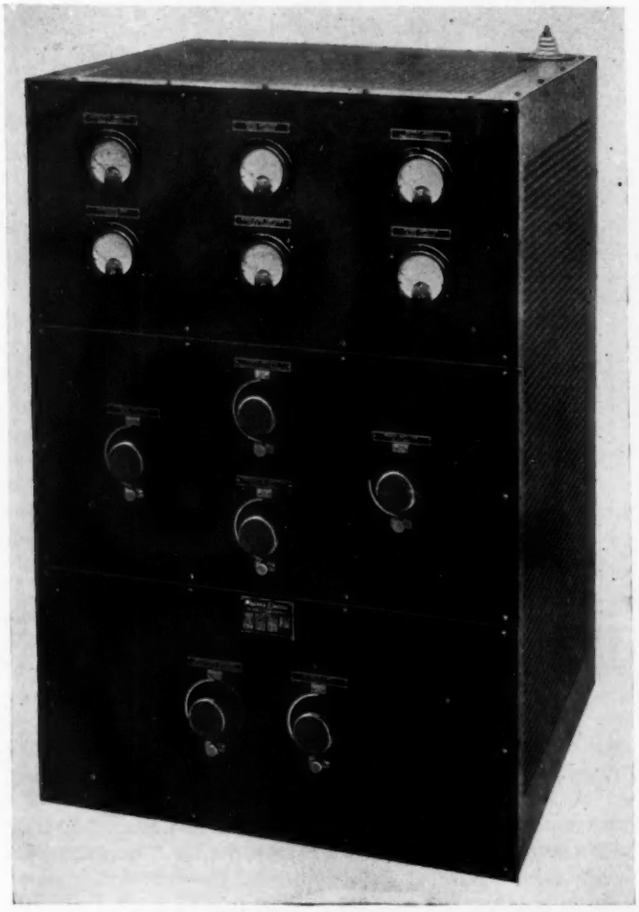

FIG. 14—HIGH-FREQUENCY 400-WATT GROUND-STATION RADIO-TELEPHONE TRANSMITTER FOR TWO-WAY COMMUNICATION

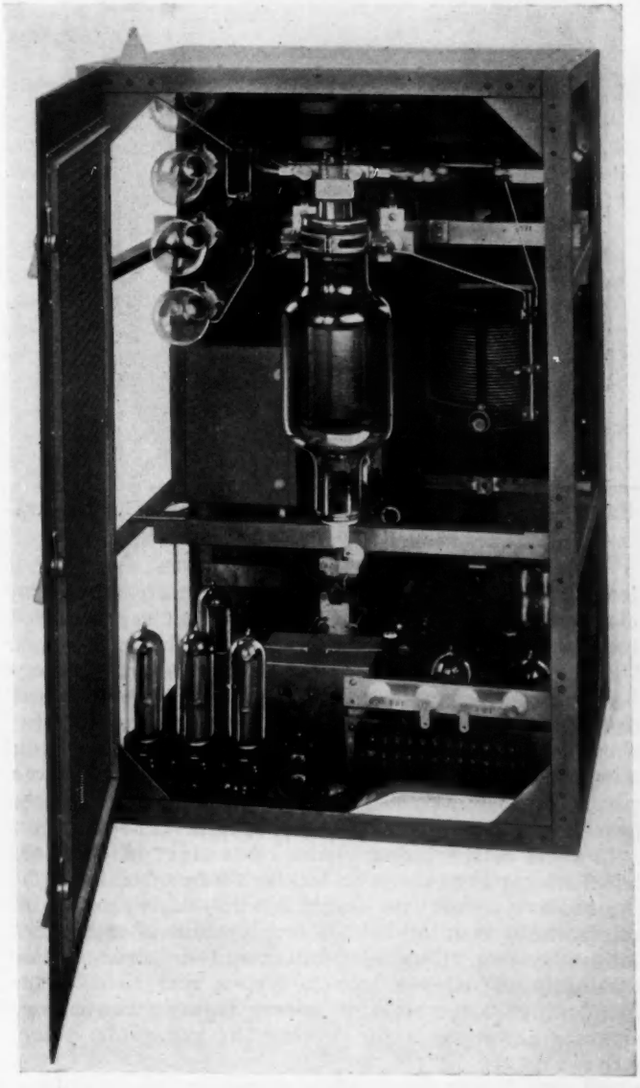

FIG. 15—REAR OF TRANSMITTER SHOWN IN FIG. 14, WITH SCREENS REMOVED

FIG. 16—ANTENNA TUNING-UNIT USED WITH GROUND-STATION RADIO TRANSMITTER

loaded power-supply system. The fact is that we are closely approaching the limit of load that can be cared for by the standard generator mounting and drive. The general adoption of electrical starters and landing-lights has greatly increased the load on the airplane electrical system. It is believed that careful consideration should be given to the practicability of employing a separate constant-speed engine of a few horsepower output for driving the generator on the larger planes, to make a more adequate power-supply available.

In some of the larger planes the weight of the electrical wiring is as much as 100 lb., 20 lb. of which is in the radio system. The weight of this wiring could be substantially reduced by the employment of a higher-voltage system. Consideration should be given to the possibility of using a 32-volt system and also to the abandoning of the storage battery through the use of separate powerplants for driving the generator. Such major changes in the airplane power-supply systems would, of course, necessitate corresponding modifications in the radio equipment.

The installation of the two-way airplane radio equip-

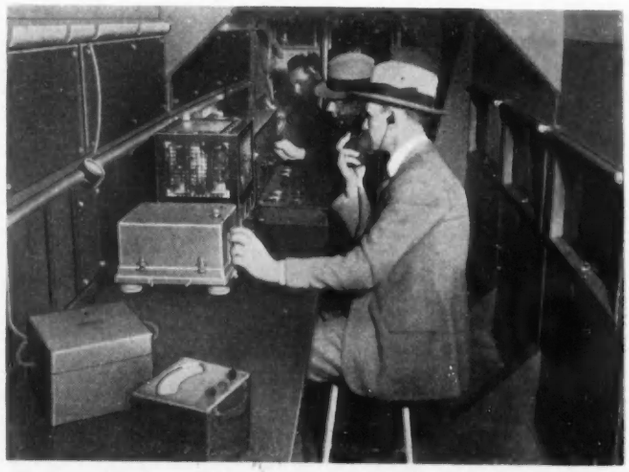

FIG. 18—INTERIOR OF TRANSPORT-TYPE AIRPLANE EQUIPPED FOR AIRCRAFT-RADIO DEVELOPMENT WORK

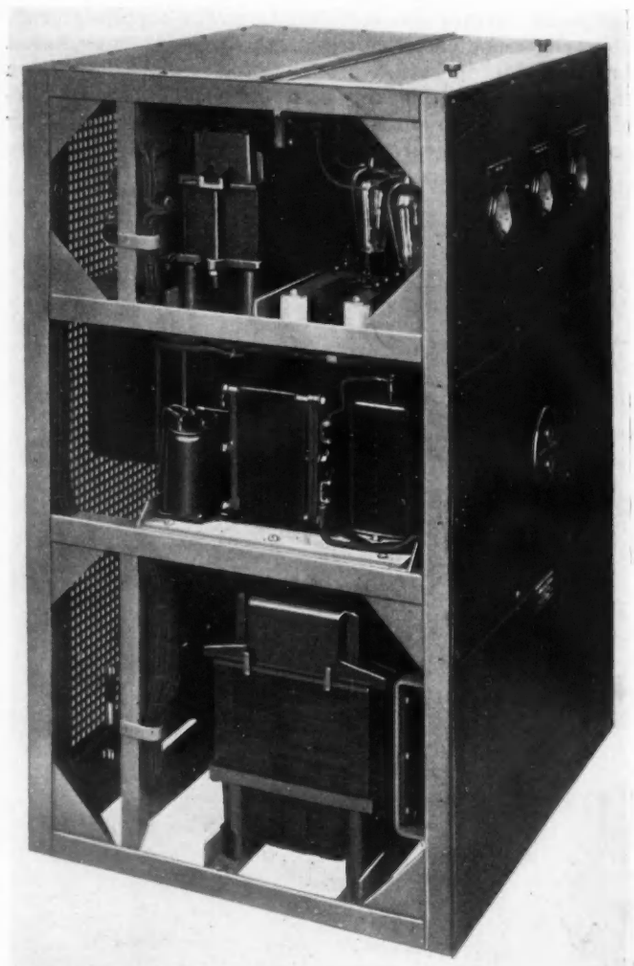

FIG. 17—RECTIFIER FOR SUPPLYING PLATE-CIRCUIT POWER AND GRID BIAS TO GROUND-STATION RADIO TRANSMITTER

ment is much more of an undertaking than that of the weather and beacon receiver. It is, however, quite simple and inexpensive if the airplane and engine manu-

(*Concluded on p.* 340)

Aircraft Powerplants

By COMMANDER E. E. WILSON, U.S.N.[1]

LOS ANGELES AERONAUTIC MEETING PAPER — *Illustrated with* CHART

THREE bases of aircraft-powerplant classification, (*a*) form, (*b*) process of cooling and (*c*) fuel-utilization method, are given by the author, who discusses briefly the major subdivisions of each. Following this he points out the necessity for establishing some basis of comparison which he gives as the six fundamental requirements that an aircraft powerplant should in general meet. These are (*a*) minimum weight, (*b*) minimum cost, (*c*) maximum fuel-economy, (*d*) maximum dependability, (*e*) maximum durability and (*f*) maximum ease of maintenance, all of which are somewhat elastic and require more specific definition.

To give an idea of the interdependence of these requisites, the author discusses their influence on powerplant design and states that the single-row radial-engine is generally the best type for aircraft work. Based on these same factors, direct cooling is better than indirect cooling, since, no matter how much the latter may be simplified, it still remains heavier, is more costly, exerts an adverse effect on powerplant dependability and durability and increases maintenance difficulties.

Continued development of the heavy-oil engine is predicted, as that type not only does not suffer when compared with the carbureter gasoline engine on the basis of satisfying the six fundamental requisites mentioned but also possesses the additional advantage of a reduced fire hazard in the air following a crash and in fuel handling and shortage.

WITH the advent of numerous new American aircraft-engines, the airplane designer is given a wide range from which to make his selection. His choice will be influenced by a number of factors and he must know these factors if he is to choose intelligently. The designer of new aircraft-engines must also appreciate the various factors involved, their influence on one another and their importance in the general problem. The purpose of this paper is to outline a basis of comparison on available engines, to compare them qualitatively, and in one respect quantitatively, and to outline the trend of development as I see it at the present time.

Three Bases of Engine Classification

Aircraft engines may be classified in three ways as to (*a*) form, (*b*) the process of cooling and (*c*) the manner of using the fuel. So far as form is concerned, modern engines fall into two general types: the radial and the in-line. The radial engine, in turn, falls into two classes: the single-row and the multi-row. In-line engines fall under four general heads: the straight line, the V, the broad-arrow or W-type and the X-type. The straight and V-types again fall under two heads: those that can be mounted vertically and those that can be mounted in the inverted position.

So far as cooling is concerned, engines fall into two classes: (*a*) the direct and (*b*) the indirect. The direct-cooled engines are those in which waste heat passes through the cylinders and directly to the cooling air. Indirect-cooled engines are those in which the waste heat is first transmitted to some other cooling medium and then to the air. The indirect process is ordinarily accomplished in two ways: through (*a*) the core-type radiator and (*b*) a surface or wing-type radiator. The cooling process can be subdivided further under three heads: (*a*) that in which water is used without evaporating, (*b*) that in which the water is evaporated and condensed in the process of cooling and (*c*) that in which a fluid of high boiling-point is used.

Aircraft engines can be classified according to the fuel they use under two heads: (*a*) gasoline or carbureter engines and (*b*) oil-injection engines. Of course, both types are oil engines but in the gasoline engine the crude oil is refined to a degree to permit its preparation for burning in a carbureter. In the oil engine the fuel is injected directly into the cylinders without being previously carbureted. The oil employed in injection engines is not a crude but like the gasoline is separately prepared for the purpose.

All modern engines can be classified according to the three heads outlined above. We are accustomed to think of air-cooled engines as meaning the modern single-row radials and the water-cooled engines as the in-line type. Manifestly this is a very loose classification. We have direct-cooled engines of the straight-line and the V-types and indirect-cooled engines of the radial type. Single-row radial direct-cooled engines using heavy oil are available. Any analysis of aircraft powerplant problems requires a more accurate classification of engines than we now popularly employ.

To compare properly the different types of engine we must establish a yardstick or a basis of comparison. Aircraft powerplants generally must strive for six requisites as follows: (*a*) minimum weight, (*b*) minimum cost, (*c*) maximum fuel-economy, (*d*) maximum dependability, (*e*) maximum durability and (*f*) maximum ease of maintenance. These six requirements are in themselves elastic and indefinite and we must define them more specifically and appreciate their influence on one another. Before attempting this definition we should pause for a moment and realize that even our term aircraft requires some consideration.

Aircraft Type Concerns Powerplant Choice

Aircraft fall naturally under two heads, lighter-than-air craft and heavier-than-air craft, and the purposes governing the employment of these two types are totally

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different and their requirements are likewise different. Heavier-than-air craft depend entirely upon their power for their flight. Lighter-than-air craft, having buoyancy of their own, may utilize buoyancy to sustain themselves. They use their power to transfer themselves from one place to another. This influence of gravity has a profound effect on the two different types. Lighter-than-air craft evidently are of much greater range and duration of flight than heavier-than-air craft. Especially is this true where pay-load is to be carried. In general, the airplane is a short-range craft of high speed and light load. The airship is a craft of long range, moderate speed and heavy load. These factors materially concern the choice of powerplant as will be outlined later.

Influence of Weight

The influence of powerplant weight in all types of aircraft is great. Not only is the powerplant weight important of itself but also because of its influence on the structure. The saying is "It takes a pound to carry a pound"; in other words, for every pound of powerplant weight a pound of structure is required to transport that weight. A reduction in powerplant weight permits a reduction in structure and a corresponding reduction in gross weight; and this, in turn, may reduce the power required to perform a given service, which in turn may result in further reduction in size. We are accustomed to speak of powerplant weight in terms of pounds per horsepower. This expression is in itself somewhat indefinite. In a given engine the power output varies with the crankshaft speed. The faster the engine runs, the higher is the power output and the lower the weight per horsepower. On this basis we may be able to develop an engine of low specific-weight but one of limited usefulness in aircraft.

In general, for best efficiency, a propeller should turn about 10 r.p.m. per mile per hr. in the airplane. Thus a machine making 100 m.p.h. should have a crankshaft speed of approximately 1000 r.p.m. for efficiency. If an engine gets its low specific weight through its ability to maintain a crankshaft speed of say 3000 r.p.m., the power attained is not available for use in a slow-speed airplane without the use of reduction gears. Reduction gearing involves weight and complications that tend to modify some of the advantages of low propeller-speeds and to increase the specific weight. Pounds per horsepower is, therefore, a measure that can properly be applied only when qualified by a statement of the crankshaft speeds to be utilized.

Comparison by Piston Displacement

A useful basis of comparison is the weight per cubic inch of piston displacement. This indicates the degree of skill with which the designer has been able to make available the necessary displacement on the minimum weight and shows clearly the influence of form on the problem. It shows, as we should expect, that as engines decrease in size their weights do not decrease in direct proportion, since the various accessories constitute a larger proportion of the fixed weight in the small engines than in the larger ones. The small engines therefore suffer by comparison with the larger ones on the basis of weight per cubic inch of displacement.

The number of approved American engines now available makes it possible to compare our engines quantitatively in this respect. This has been done in Fig. 1, in which displacement in cubic inches is plotted against engine weight in pounds. The data for this figure are taken from the National Advisory Committee for Aeronautics Technical Note No. 303, Condensed Data on Aircraft Engines of the World, compiled by C. S. Fliedner, of the Bureau of Aeronautics in the Navy Department. Fortunately, we have a number of engines built in series such as the Whirlwind J-6 five, seven and nine-cylinder engines and the LeBlond with three, five and seven cylinders. While the other approved engines are not built in series, they can nevertheless be grouped together as a basis of comparison.

Referring to the chart, we find that a line drawn through the displacement figures for the Wasp, Hornet and Cyclone engines and compared with one drawn through the Curtiss D-12 and V-1570 engines shows conclusively the superiority of the 9-cylinder single-row radial over the 12-cylinder 60-deg-V engines. The difference is even more apparent when these radials are compared with the Packard and Liberty. A line drawn roughly through the Velie, Kinner, Warner-Scarab, Comet and Challenger engines and prolonged through the Whirlwind series gives us a good idea of the weights per cubic inch of the radials. By comparison, the four-cylinder in-line engine of low power shows up unfavorably. The position of the Wright V 1460, which is a direct-cooled 60-deg. V-engine, and the Allison V 1410, a 45-deg. V direct-cooled type, show the inherently greater weight of air-cooled in-line engines. This is the inevitable result of cylinder separation made necessary to permit the air to flow and cool the cylinders. From the point of view of weight per cubic inch of displacement, the single-row radial is superior to other forms.

Factor of Powerplant-Accessories Weight

Powerplant weight must take into consideration all the factors involved in it. The weight of the indirect-cooled installation must include those of the radiator, the piping, the circulating pumps and other parts and may be required to include the tankage for fuel and oil and the weight devoted to oil cooling, if that is required. Manifestly, the fuel-tank and oil-tank weights are dependent on the quantity to be carried. This will depend upon the economy of the engine and more largely upon the service in which the airplane is to be used.

In a long-range airship the total fuel and oil load may be very large in proportion to the fixed powerplant-weight. A 10-per cent improvement in fuel economy may bring about a large reduction in the gross weight. A 10-per cent reduction in the fixed powerplant-weight might produce a comparatively small reduction in the gross weight. In an airplane, however, if the range is short a greater reduction might result from an improvement in the fixed powerplant-weight.

In comparing the different powerplants we must keep in mind the type of service in which the powerplant is to be employed. No fixed measure can be established. The problem is not so simple that we can apply a rule of thumb to it.

Fundamental Requisite Considerations

Powerplant cost involves many variables and may be divided into the initial cost and the operating cost. The former is largely a function of quantity production, in aircraft as in other mechanical devices. Quantity production has a larger influence on initial cost than has

detailed design. In operating cost, ease of maintenance and durability enter into the problem. Engines are subject to two classes of overhaul: top overhaul and major overhaul. The intervals between these classes of overhaul and the matters involved in the overhaul are important items of cost that may be strongly influenced by design. The form of the engine and the method of cooling are two important factors in the cost.

Fuel economy is more important perhaps from the viewpoint of possible increase in pay-load than from that of cost of fuel. As in other forms of transportation, fuel costs are a comparatively small part of the total operating-cost. A reduction in fuel that brings about an increase in pay-load may prove to be important. Fuel economy is a function of the powerplant design as well as of the airplane design. The two overlap, as has been outlined above in connection with the choice of the propeller. Close coordination is required to bring results. Engine economy is a function of the expansion ratios that can be employed. These in turn are dependent upon the fuel available and that employed and must be kept in mind when comparing powerplants.

Dependability, which may be defined as freedom from failure, has three factors: (*a*) the engine itself, (*b*) the powerplant as a whole and (*c*) the effectiveness of the ground organization. In considering our powerplants from the standpoints of form, cooling and fuel, we must keep these three factors in mind.

From the point of view of durability we may consider an engine from the aspects of (*a*) life between overhauls and (*b*) total life. Durability influences cost, not only from the point of view of initial cost but also from that of operation and the cost of overhaul.

Ease of maintenance is largely influenced by accessibility. Dependability requires frequent inspections and routine checks on the part of ground crews. The principle here is that of preventive engineering or the elimination of faults before accident occurs. Ease of maintenance will therefore influence the cost of this maintenance. Inaccessible parts make for carelessness in inspection. Ease of maintenance enters into top overhaul. If repairs and renewals can be made readily in the field, durability, dependability and cost are influenced.

Comparison of Radial and In-Line Types

With these bases of comparison established and generally defined, we may now proceed to the comparison of the different types of engine, the radial with the in-line engine, the direct-cooled with the indirect-cooled engine and the different classes of radial and in-line direct and indirect-cooled engine one with another.

From the weight angle the single-row radial is attractive; its compactness gives it a weight per cubic inch of displacement that is very interesting. The single-row radial is attractive from the viewpoint of cost; its form lends itself well to quantity production. On the fuel-economy basis the radial is interesting because of its weight advantages. The radial form makes for simple, clean-cut and readily accessible installation, which in turn promotes durability and dependability. Between the direct and indirect-cooled radial the choice is all in favor of the former as regards weight, cost, economy, dependability, durability and ease of maintenance. Indirect-cooling systems are heavy, expensive, uneconomical, unreliable and difficult to maintain.

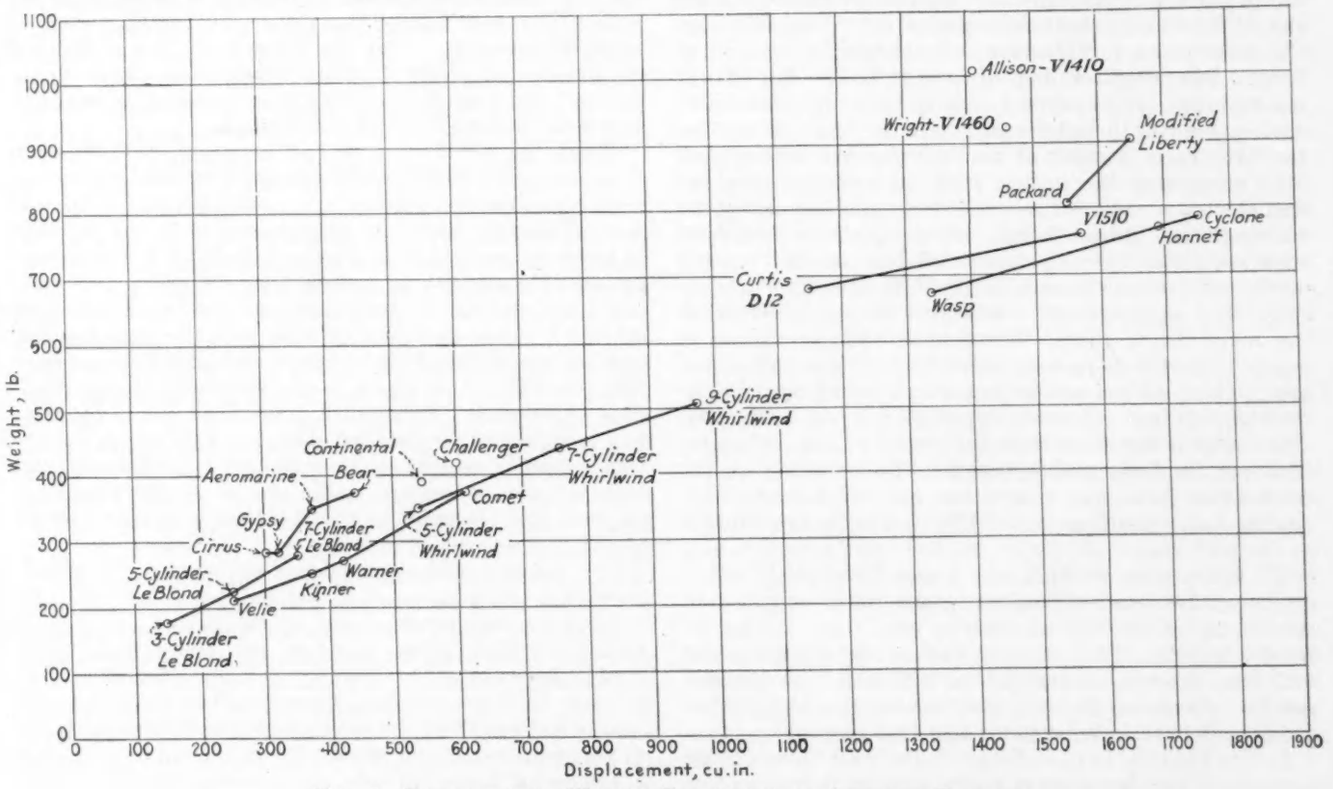


FIG. 1—DISPLACEMENT-WEIGHT RELATIONS IN AIRCRAFT ENGINES

This Chart, Which Is Based on Data Taken from the National Advisory Committee for Aeronautics Technical Note No. 303, Shows the Superiority of the Single-Row Radial Engine with Direct Cooling over the V-Type with Indirect Cooling and the Direct-Cooled In-Line Engines

In choosing between the single and the multi-row radial we find certain advantages in each. The latter offers an increase in the number of cylinders available on a given circumference, with corresponding reduction in diameter and interference with vision. But if the number of cylinders is increased for a given displacement, this reduction in diameter invariably is obtained only with increased weight and cost. Modern single-row radials employ the solid connecting-rods and split crankshaft to eliminate the old big-end bearing difficulties encountered when split connecting-rod radials were run at high crankshaft-speeds. The double-row radial eliminates the use of the solid connecting-rod. In the choice between the single and the multi-row radial the determining factor is the price we are willing to pay for improved visibility.

Interference with Visibility

In this connection the interference with visibility ahead is largely a function of the design of the airplane. Variation in the position of the pilot's seat with respect to the engine is a factor, but the power of the engine and its corresponding size in proportion to the airplane are the greatest factors. In low-power airplanes the engine is already small in proportion to the cross-section of a fuselage that will hold a man. In the high-power combat airplanes the single-row radial interferes materially with visibility ahead, and this, unfortunately, is exactly the type of airplane in which visibility ahead must be excellent.

Of the in-line engines the X-type is the most compact and should, therefore, have the least weight. For a given displacement this type will be more costly than the W, the V or the in-line. No one of these engines should have important advantages over the others in the matters of fuel economy, dependability and durability. The simplest engine is manifestly the easiest maintained. The inverted in-line type should find its application in installations where it has advantages from the point of view of non-interference with vision.

In comparing the in-line with the radial engine, we find the latter superior as regards weight because of its compactness. Other things being equal, it should be superior from the cost standpoint because of the simplicity with which it adapts itself to quantity production. The single-throw crankshaft seems superior to the multi-throw shaft. The forged split crankcase is superior to the long cast crankcase of the in-line engine. There should not be important advantages in the matters of fuel economy, dependability or durability. The radial is superior from the aspect of ease of maintenance; its form makes possible the grouping of the accessories in a way that gives ease of access. This engine lends itself more readily to simple installation in the airplane.

Up to the present time, our 6 and 12-cylinder in-line engines have been superior to our radial engines in smoothness of operation. This is partly due to the inherent balance of the engines having six cylinders and multiples thereof, as contrasted with the nine-cylinder radials. As passenger-transport operation develops, the radial will have to be improved in this respect.

In-line engines have suffered in the past through the location of the accessories and accessory drives on the anti-propeller end. This places the accessory drives at a point where they suffer from torsional whip of the crankshaft, a fact has required unnecessarily heavy gears or the introduction of spring couplings. Location of the accessories and the accessory drive at the propeller end should improve this condition.

Our in-line engines are largely of overhead-valve type, with camshafts mounted in the housing that secures the cylinders together. This arrangement has obvious advantages but also certain disadvantages. Removing one cylinder, for instance, necessitates taking out the camshaft and the housing, an arrangement that compares unfavorably with the radial engine, from which a single cylinder can be removed without interfering with any other part. Some engines can be and are built with push-rod-operated valves and thus retain their accessibility at the cost of multiplicity of parts and lubrication difficulties.

Certain of our in-line engines can be run in the inverted position while others cannot. The ability to run inverted is believed to be a fundamental requirement. In certain specific installations this necessity is immediately apparent. An analysis of the vision-interference problem shows the superiority of the inverted in-line engine over the vertical in-line or the radial engine, particularly in high-powered installations in small airplanes.

Direct versus Indirect Cooling

The direct-cooling process has the advantage over the indirect process from the viewpoints of weight, cost, dependability, durability and ease of maintenance. No matter how much the indirect process may be simplified, it still must be heavier than the direct. Since the cooling system is additional equipment, it must make the powerplant more costly and, since it involves piping and additional apparatus directly affecting the dependability and durability of the powerplant, its effect must be adverse. Also the upkeep of this additional equipment, involving keeping connections tight, flushing out the system and changing the cooling medium, increases the difficulty of maintenance.

From the standpoint of fuel economy, the situation depends upon other circumstances. If the engine design and the installation are such that the cylinders are adequately cooled at all speeds and if the mixture is properly vaporized in both installations, neither process should have any advantage over the other. If, however, the cooling is inadequate so that recourse must be had to over-rich mixtures to cool the direct-cooled engine, and some of the direct-cooled installations have had this fault, then, manifestly, the indirect-cooled engine is superior. This defect is not inherent in the type but is due to poor detailed design. The rotary induction-system equipped with carbureter-air-heaters and hot-spots in the modern radial engine should give fully as good fuel economy as the jacketed induction system of the indirect-cooled engine.

Our indirect-cooling processes are three in number, involving (*a*) water below the boiling point, (*b*) the evaporation and condensation of liquid and (*c*) liquids of high boiling point that are not evaporated. The straightforward water-cooling system should be the heaviest of these. The high-temperature liquid process results in less liquid and smaller cooling-surfaces. Based on cost considerations, the choice of the three processes is somewhat indeterminate. High-temperature cooling should be the choice from the viewpoint of fuel economy because of the reduction in weight and drag in the apparatus and the improvement in distribution resulting

from higher intake-manifold and jacket temperatures.

Choosing between the water system, the evaporating process and the high-temperature process would appear hard on the basis of dependability and ease of maintenance, and the three are hard to compare from the standpoint of durability, although theoretically the high-temperature process has apparent advantages.

Experience is required to be able to answer these questions. If certain services demand the employment of the indirect-cooled engine, the high-temperature cooling-process seems attractive. At best, however, it is an indirect process with inherent complications and can be adopted only where other considerations outweigh these.

When comparing the direct-cooled radial with the indirect-cooled in-line engine, the custom is to contrast frontal area to the disadvantage of the radial. Many of these comparisons neglect to include the radiator in the frontal area of the in-line indirect-cooled engine. They also often neglect the masking effect of the fuselage behind the engine. Only recently is the fact that a fuselage of small cross-section is not necessarily one of little resistance becoming appreciated. A better fineness-ratio may readily result from a clean fuselage of ample cross-section and correct proportions. Actual comparative tests demonstrate conclusively that when all variables are considered the drag due to the single-row direct-cooled radial properly installed is about equal to that of the indirect-cooled in-line engine. In general, the drag required to dissipate heat through the cylinder-walls may be said to be about the same in each case. As a concrete illustration of the unsoundness of head-resistance criticism of the radial, we have the striking performance of the Travel Air at the recent Cleveland races. The venturi cowling has served to disprove early contentions as to speed possibilities in the two types, at least in the range of present commercial speeds that are now equal to the racing speeds of a few years ago.

Carbureter-Type and Heavy-Oil Engines

As regards weight, little reason exists for choosing between the carbureter engine and the heavy-oil engine. While the design may require certain increased structural weight because of the higher pressures in the oil engine, nevertheless the elimination of some of the heavy accessories of the gasoline engine should partially compensate for this. Aircraft magnetos, like most electrical appliances, are heavy in proportion to the service they perform. The injection apparatus should not weigh more than the combined gasoline carburetion and ignition equipment. As development proceeds the two engines should be about comparable from the aspect of weight. The standpoint of cost leaves little to choose between the two engines. In quantity production the initial cost should be comparable. After comparable development, the operating costs should not be different. Slight advantages in favor of the Diesel may exist because the electrical accessories of the gasoline engine are very expensive. Nothing is inherent in either type that indicates superiority in the items of dependability, durability and ease of maintenance, and comparable development should leave small latitude for making a choice.

From the angle of economy the heavy-oil engine may possibly be superior but whether this economy can be attained remains to be seen. Heavy-oil engines will have to compare with gasoline engines on the weight-per-horsepower basis and they must be capable of operating at the high crankshaft-speeds that are possible with the carbureter engine. As speeds are increased the difficulty of obtaining economy is likewise increased. The answer to this question is one that must await further detailed development.

The high crankshaft-speeds that we are now using without reduction gears in some of our slower aircraft are far from economical; possibly we have gone too far in the effort to obtain low weight per horsepower through high crankshaft-speeds. An oil engine that is limited to approximately 1300 or 1400 r.p.m., while heavier as measured in pounds per horsepower developed at that speed, after running a few hours may burn less fuel and have a smaller total powerplant-weight than a gasoline engine of lower specific weight attained at the expense of high crankshaft-speeds and low propeller efficiency. This conclusion is confined to low-speed aircraft. Speeds are steadily increasing, however, and the advent of the controllable-pitch propeller will again modify conclusions.

The lower price of heavy oil may or may not be an important factor in the future. As the employment of heavy-oil engines becomes more general the price of the oil is likely to approach more nearly the cost of gasoline. Too much emphasis cannot be placed, therefore, on the cost of fuel.

Comparison on Fire-Hazard Basis

One of the more important factors in the whole aircraft-engine problem is the reduction of fire hazard that may result from the use of oil, rather than gasoline, provided always the type of oil that can be used is sufficiently safe to bring about the advantage. The fire hazard is important from three different aspects: (*a*) the danger of fire in the air, (*b*) danger of fire after a crash and (*c*) danger of fire in handling and storage.

Care in design will reduce to a very low degree the fire hazard in the air. Even with gasoline the modern radial is superior to the V-engines in this respect because the carbureter has been brought out into the open where leaks are less likely to result in fire. The latter type of American engine, with fuel lines completely filling the V and the carbureter in close proximity to the spark-plugs and the ignition apparatus, presents a grave fire hazard.

The likelihood of fire after a crash can be greatly reduced by taking care in installation. This has already been done and the direct-cooled radial engines are superior in this respect to the indirect-cooled in-line engines. In a forced landing resulting from engine failure the air-cooled engine has usually time to be thoroughly cooled off before landing, whereas the indirect-cooled installation tends to retain its heat.

The heavy-oil engine has a great superiority from the viewpoint of safety in fuel storage and handling. This is particularly impressive in Naval operations aboard ship, particularly the carriers, on which large quantities of gasoline are handled. Extraordinary precautions have to be taken to prevent accident and these could be greatly reduced if oil were used as the airplane fuel.

The advantages resulting from a reduced fire hazard are sufficiently great to warrant the acceptance of the oil engine even at the expense of some additional weight and cost and lessened durability and ease of mainte-

nance. The engine must, of course, sacrifice nothing in dependability. Our analysis indicates that as development proceeds the heavy-oil type need not concede anything in weight, cost, durability and ease of maintenance; the increase in economy and safety need not cost us anything from these viewpoints.

Must Develop Oil-Engine Dependability

Therefore, all that remains is to develop the engine to the high degree of dependability that has been reached in the gasoline engine. If this could be attained, the heavy-oil engine would supersede the gasoline engine. Whether such a result can be secured remains to be demonstrated. Considerable difficulty attaches to the process of metering minute quantities of oil with great accuracy and the burning of oil at high speeds. Lighter-than-air craft can afford to sacrifice weight, cost, durability and ease of maintenance, if sufficient economy can be obtained in fuel consumption to compensate for the greater fixed powerplant-weight in certain of the oil engines. While dependability is essential in the airship, the stopping of one or two engines is not fatal, since the ship has its own buoyancy and access can be had to the powerplant to effect repairs. The first application of the heavy-oil engine, therefore, should be made in airships.

[2] See *Transactions of the American Society of Mechanical Engineers*, vol. 50, part 1, 1928, Paper No. AER 50-17.

In a paper entitled, The Oil Engine and Aeronautics[2], that I presented before the Metropolitan Section of the American Society of Mechanical Engineers in November, 1927, an outline was given of the course the heavy-oil engine-development should pursue. I pointed out that it should begin where the gasoline engine left off, taking full advantage of the development already made in direct-cooled radial gasoline-engines. Certain developments have already gone far along this line. No difficulty should be experienced in cooling by the use of the direct system an engine that burns heavy oil as fuel.

Summary

To summarize the foregoing, we find that engines may be classified as to form, process of cooling and kind of fuel used. Comparing engines from the standpoints of weight, cost, fuel economy, dependability, durability and ease of maintenance, we find the single-row radial generally advantageous. We find the direct-cooled process generally advantageous from the same six standpoints. We find further that the heavy-oil engine should not suffer by comparison with the gasoline engine from these standpoints but should profit from reduction in fire hazard. This analysis points straight to the continued development of the oil engine. The signposts of progress clearly indicate the path to be followed.

Radio Facilities for Aircraft

(*Concluded from p.* 334)

facturers have anticipated its possibility and provided for the following:

(1) Complete shielding of the ignition system, including the magnetos, booster, plugs, switches, and so forth
(2) An adequate charging generator and large battery, with all wiring completely shielded
(3) Complete shielding of all light-wiring and switches
(4) Complete bonding of all metal parts of the plane
(5) Fixtures for supporting a mast antenna
(6) Mounting brackets and supports for all apparatus units
(7) Conduit run fore and aft in the plane to carry the principal wires (See Fig. 8)
(8) Housings for flexible shafts for remote control of radio receivers.

Many of these things may be provided at far less cost at the time the plane is constructed than at a later date. It is especially important that the work of shielding and bonding be done in a thoroughly workmanlike manner, as small gaps in the shielding and loose connections in the bonding will give rise to a great deal of interference.

Ground Stations

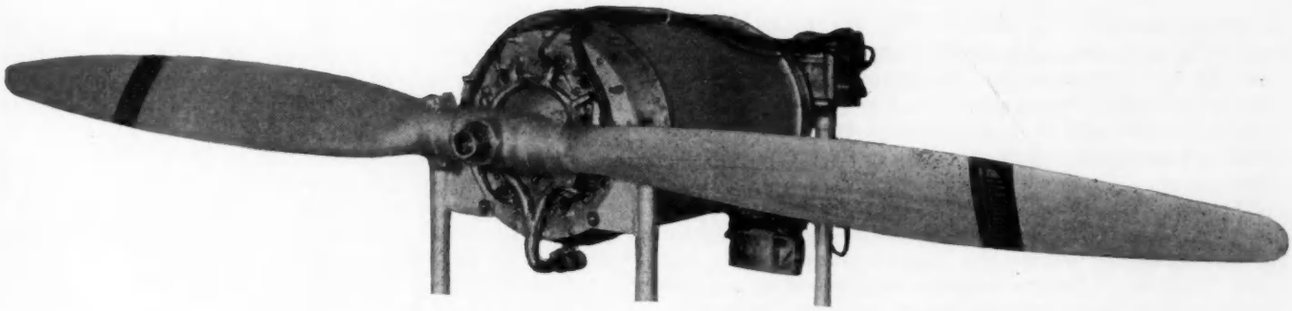
The fixed terminal of the two-way aircraft radiotelephone system may be of less current interest than the airplane equipment. It is, however, of equal importance from the standpoint of the system as a whole.

The radio receiver is similar to the high-frequency receiver used in the plane. The transmitter is more powerful than the plane set, having a carrier power output of 400 watts. Like the airplane transmitter, it is capable of complete modulation and is crystal controlled. In fact, in circuit design it is substantially the airplane transmitter circuit with an additional stage of radio-frequency power amplification. A radiation-cooled vacuum tube of 1-kw. rating is employed for this purpose. Figs. 14 and 15 show this transmitter, and Fig. 16 shows the tuning unit employed for coupling it to the antenna system.

The ground-station transmitting equipment requires about 3.5 kilovolt-amperes of three-phase, 220-volt, 60-cycle power for its operation. The power control and protective devices are all contained in the rectifier unit, which is shown in Fig. 17. The 1000 and 2500-volt plate-power supplies for the transmitter are furnished by three-phase hot-cathode mercury-vapor rectifiers in this unit. A single-phase rectifier of the same type furnishes the grid biasing voltages for the transmitter.

Conclusion

This paper has described airplane radio-telephone equipment suitable for the present needs of aviation. With an increase in the number and size of planes used on American transport lines, new radio requirements will be encountered. Continuing radio studies promise that aircraft radio-communication development will keep abreast of aircraft development. The Bell Telephone Laboratories employs two airplanes exclusively in the continuance of its radio development work. The interior of the larger one, a Ford all-metal, tri-motored plane, is shown in Fig. 18.



A Compact Aeronautic Engine

By H. W. Earl[1]

Northwest Section Meeting Paper — *Illustrated with* Photographs

SEVERAL forms of cam were experimented with for transforming the reciprocating motion of the piston into the rotary motion of the engine shaft before the crank and connecting-rod were definitely recognized as the most advantageous mechanism for the internal-combustion engine of the horseless vehicle. Engineering brains have since been concentrated on the development of engines embodying this mechanism.

The head-resistance of engines of conventional types is so great that the author attacked the problem of developing an engine of the most advantageous aerodynamic form. The result is a light engine having parallel cylinders grouped radially around a central shaft, the over-all diameter being within the dead area at the center of the propeller. A cam and rollers convert four piston strokes into one rotation of the camshaft, giving a desirable propeller-speed directly. Rotary reciprocation is imparted to the sleeve valves by cams mounted on the main shaft. A system of ports and passages gives ignition in each cylinder from the next preceding cylinder, after the engine is started, providing for engine operation without electrical ignition in case of ignition failure or during radio communication, but electric ignition is employed for starting.

BEFORE the advent of the automobile, engineers were experimenting with various types of the internal-combustion engine as the motive power for the horseless carriage. Experiments were made with different methods of transforming into rotary motion the power resulting from the explosion of the gas; among them were the crank and connecting-rod and several forms of cam. The crank and connecting-rod method was recognized as the most advantageous for the object then at hand; all other types were thrown into the discard, and the engineering brains of the world were concentrated upon the development of this type into the present highly efficient automobile engine.

The principles of the airplane, which is primarily a huge kite, have been known to man for several centuries, but artificial flight had to wait for the invention of the internal-combustion engine and the screw propeller. These two inventions, applied to the kite with the ingenuity and persistence of the Wright brothers, resulted in the first flight with a man-carrying heavier-than-air flying-machine and startled the entire world. To accomplish this, the Wright brothers had to build their own engine. They adapted the automobile engine to their needs by making it as light and small as they could, but still it weighed 15 lb. per hp.

In designing a powerplant for an airplane, it is not only necessary to ascertain definitely the power requirements of the aiplane, but the aerodynamics of the operation must be given the most careful consideration. George F. McLaughlin[2] specified the seven major requirements of aircraft engines as follows:

(1) Minimum weight per horsepower
(2) Minimum consumption of fuel and oil
(3) Minimum frontal area or head-resistance
(4) Maximum reliability
(5) Maximum durability
(6) Minimum initial cost
(7) Minimum cost of maintenance

To these requirements we may add two more:

(8) Speed to secure greatest efficiency and no noise from the propeller
(9) Maximum unobstructed view ahead for the pilot

Minimum engine weight and head-resistance and correct propeller speed are generally conceded as the most important factors of the problem; while fuel efficiency, reliability and durability are more or less taken for granted. In discussing these requirements, I shall briefly touch upon the latter group first.

Possible Thermal Improvements Are Not Great

While fuel consumption should be kept down to the minimum at all times, we know that we are getting a thermal efficiency of only about 25 per cent from the present explosion type of engine and only a little higher percentage from the Diesel type. In gasoline engines,

[1] President, Earl Aircraft Corp., Portland, Ore.

[2] See Annals of the American Academy of Political and Social Science, May, 1927, p. 34.

a fuel consumption of about ½ lb. per hp-hr. is considered a good average, and the chance for improvement in this direction at this time seems to be small. The most needed improvement in the way of fuel consumption just now is a substantial reduction in the minimum amount of fuel required to fly an empty airplane.

At least 25 per cent of the fuel required merely to fly an airplane is estimated to be consumed to sustain the weight and overcome the head-resistance of the engine. This non-effective weight and resistance should be reduced to the minimum before making further attempts to improve the thermal efficiency.

Can Increase Reliability and Durability

Reliability and durability are taken for granted in the construction of all gasoline engines, yet the durability and resulting reliability of the aircraft engine can be greatly increased by the simple expedient of eliminating from its structure those mechanical parts which have proved to be the most frequent sources of trouble, such as gears, springs, poppet valves and babbitt bearings.

Pilots have been flying with their view ahead obstructed by the engine ever since air-cooled engines came into general use. This fact proves that unobstructed visibility in the line of flight is not generally of such vital importance as some other factors. However, it becomes a safety factor of greatest importance when flying through thick weather or over mountainous regions and in making forced landings in difficult places, and it will assist pilots in avoiding collisions with mountains and tall trees and smash-ups when landing.

One of the prime factors in aircraft-engine design is low weight per horsepower. Decreasing the weight of the engine without diminishing its power makes possible an increase in the pay-load without enlarging the craft. Furthermore, aircraft engineers say that, for every pound eliminated in engine construction, up to two additional pounds can be eliminated from the weight of the airplane by reducing the size of its structural members, without reducing its net carrying capacity. If the weight of the conventional 200-hp. engine were reduced from 2½ lb. to 1 lb. per hp. and the weight of the plane were reduced an additional 3 lb. for each 1½ lb. thus saved, the total saving in the weight of the engine and airplane would amount to 900 lb. While this seems hardly possible, it illustrates forcefully the importance of engine weight in the design of both the engine and the plane.

Reducing the Head-Resistance

With the speed of planes mounting from year to year, head-resistance also is mounting to alarming proportions. In relation to the consumption of power, head-resistance is more important than excessive engine-weight because power consumption due to weight remains constant, whereas that due to head-resistance varies with the air-speed of the plane. Head-resistance is of such great importance that all possible parts are streamlined, including guy wires and the smallest fittings.

To reduce head-resistance, engine cylinders should not protrude into the air as air-cooled cylinders do. They present a frontal area varying in diameter from 40 to 60 in., creating excessive head-resistance and eddy currents. The new cowling device for air-cooled engines is a good development, but I do not know to what extent it reduces the head-resistance. If the reduction is one-half, the remaining one-half is still far too great.

Another important consideration is that this device, covering an engine 50 in. in diameter, is close to the propeller and interferes with part of the effective portion of the propeller blades. The saving in power by the reduction of head-resistance is therefore partly offset by a corresponding reduction in propeller efficiency.

A certain dead area surrounds the hub of the propeller. This varies according to the design of the propeller and averages about 24 in. in diameter. The minimum head-resistance from this part of the airplane can be attained when this dead area is covered with a spinner and the nose of the fuselage is designed to correspond therewith, the whole being streamlined into the cockpit or cabin.

An engine extending beyond the limits of this dead area, even in one direction, creates a condition which offers resistance to flight, and the penalty is increased cost of operation. The ideal condition for minimizing head-resistance from the engine is to design it to fit into the cowling of a well-streamlined fuselage. This would effect a great saving in the cost of operation.

Liquid-Cooling or Air-Cooling?

Air-cooling is not uniform at all points and requires lower compression than does cooling by a liquid that is circulated around the walls of the combustion-chamber. Consequently, efficiency is lower and fuel consumption is higher with an air-cooled engine than with a water-cooled engine.

Very little was heard about the radial air-cooled engine until the famous flight of Col. Charles A. Lindbergh. Since then, this type of engine has received a great amount of publicity, and many aviators and engineers now regard it as far superior to the liquid-cooled type; but I believe that the air-cooled engine falls far short of being the superior type.

The liquid-cooled engine is generally admitted to be more rugged and to withstand hard usage longer than can the air-cooled engine. S. D. Heron, mechanical engineer in the Materiel Division of the Air Corps, at Wright Field, says[1]:

> The experience of the Air Corps is that a high-temperature liquid-cooled engine will stand much more abuse than any air-cooled engine that has yet come under observation. The Air Corps has yet to test any air-cooled engine which will equal the low fuel-consumptions given by high-temperature liquid-cooled engines. At any given compression-ratio or on any given fuel used to date, the glycol-cooled engine has shown that it can very materially better the fuel consumption obtainable from the best air-cooled engines.

Probably both types of engine will always remain; but the liquid-cooled engine looks like the coming type, especially for the larger installations.

Engine Speed and Propeller Efficiency

One important disadvantage of both water and air-cooled engines now in use is the great sacrifice of propeller efficiency due to the mechanical operation of all crankshaft engines. The peak of propeller efficiency, the point at which the propeller delivers the most pull

[1] See S.A.E. JOURNAL, October, 1929, p. 343.

to the craft for the amount of power consumed, is at about 1000 r.p.m. Piston speeds have been increased to give more power without increasing the weight, giving to the crankshaft much too high speed for good propeller efficiency.

The propeller pull does not increase at the same ratio as the speed, above 1000 r.p.m., because of an increasing rate of slippage. The propellers of the seaplanes which recently flew in England at about six miles per minute were geared down to 1500 r.p.m. from engines running at 3000 r.p.m. This should dispel any idea that it is necessary to run the propeller at high speed to make the airplane fly fast.

I take this opportunity to protest against the rating of aircraft engines according to brake horsepower. Pull, in pounds, is what makes the airplane fly; that is the only thing in which the engineer is interested when rating an aircraft engine. Therefore, aircraft engines should be rated with relation to the amount of net pull delivered instead of in brake horsepower on the test stand.

Power Loss by High Propeller-Speed

Assume two engines of 100 hp. each. If one delivers its power to the propeller at 1000 r.p.m. and the other at 2000 r.p.m., there will be a great difference in their actual ability to pull the airplane. The propeller that is turning at 1000 r.p.m. is delivering the maximum pull, while the 2000-r.p.m. propeller is sustaining a loss of from 15 to 20 per cent in propeller efficiency or pounds of pull delivered. Deducting a loss of 15 per cent, the pull delivered by the second engine is only 85 per cent of the maximum pull of the first engine; hence, the first engine remains a 100-hp. engine, while the second proves to be only an 85-hp. engine in net result. Still, each engine is developing 100 hp. and consuming the same quantity of fuel.

As another illustration, the normal 400-hp. radial engine turns the propeller at about 2000 r.p.m. A loss of 25 hp. results from the head-resistance in driving this engine through the air at 100 m.p.h. A further loss of 15 per cent, or 60 hp., results from too high propeller-speed. These losses reduce to 315 hp. the net power delivered to the airplane. Assuming the possibility of an engine weighing 1 lb. per hp., the excess weight of the present normal engine and the extra weight of the structure required to support it cause an additional loss of 25 hp., that is required to carry the unnecessary weight.

If engine designers will meet the demand of airplane designers by producing an engine weighing not more than 1 lb. per hp. and turning its power shaft at a normal speed of 1000 r.p.m., 300 hp. in such an engine will do the work now done by a 400-hp. radial engine, with a saving of 25 per cent in fuel consumption.

Another important point in favor of slow-turning propellers is that they eliminate the terrific noise produced by the smaller and faster propellers. If flying is to become as popular as we desire, this noise must be eliminated or at least greatly reduced, and this can be done only by reducing the propeller speed.

A marked tendency is seen, especially in larger units, to gear down the propeller to run at more efficient speeds. While this apparently accomplishes the purpose, the gears add weight, consume power and add the possibility of being stripped.

Disposal of the Cylinders

The use of a crankshaft in engine design fundamentally necessitates placing the cylinders at right angles to the crankshaft. The water-cooled engine requires a heavy cylinder-block, a quantity of water or other cooling medium, and a radiator, all of which involve excessive weight and head-resistance for aircraft use. The total weight is reduced in the air-cooled engine, but the additional head-resistance caused by the radial disposition of the cylinders offsets the gain made by the reduction in weight.

This leads to the conclusion that placing the cylinders at right angles to the power shaft, whether a crankshaft or camshaft, violates the fundamental laws of aerodynamics and sets up conditions that are adverse to flight.

In an interview which appeared in the *Morning Oregonian*, May 26, 1929, Henry Ford said:

> There is not the slightest sign yet of the specific kind of engine which aviation must develop. When the steamboat came, it developed the steam engine; when the automobile came, it developed the gasoline engine; but where are the engine and the fuel that are to be identified with aviation? Thus far we have done nothing really new in aviation; the great thing that must be done, and along essentially new lines, is to get a new type of powerplant which will produce more power with less weight.

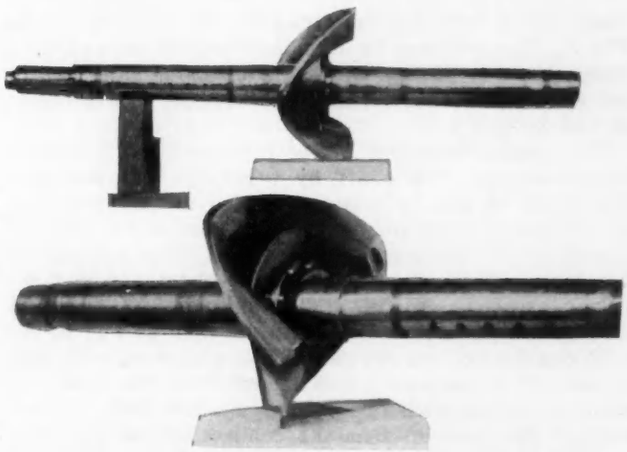


FIG. 1—CAMSHAFT ASSEMBLY OF EARL ENGINE

This Main Shaft Comprises Hollow Front and Rear Sections and a Power Cam. Cams for Sleeve-Valve Operation Are also Mounted on This Shaft. Mixture Is Fed Through the Shaft

While running tests for the Government in 1917, and having in mind the difficulties encountered in adapting the automobile engine to aircraft use, I conceived the idea of disregarding all existing types of engine and allowing the specific requirements of aviation to dictate the design of its powerplant. With this in mind, I set to work to discover what form such an engine should have to comply with the laws of aerodynamics that control flight. After drafting on paper several forms of cam, I recognized the advantages of the four-point circular cam for applying the power of exploding gas to the rotation of the propeller. During the next 10 years I spent my spare time in designing an aircraft engine based on this principle.

An Engine Design Based on Aerodynamics

The result of this work is the Earl aircraft engine, shown at the head of this paper, which is now being developed by the Earl Aircraft Corp. This is a four-cycle gasoline engine, cylindrical in form, 17½ in. in diameter and 52 in. long over-all. The two-part, hollow propeller-shaft is straight, extending through the center of the engine. A four-point circular cam, located in the center of the engine, is bolted to the propeller-

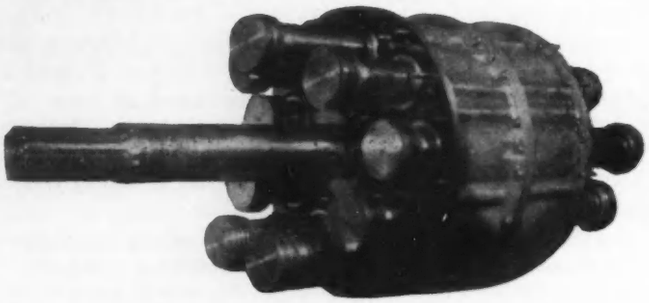


FIG. 2—CENTRAL PORTION OF ENGINE, WITH CYLINDER-BLOCKS REMOVED

shaft, thus forming the integral assembly shown in Fig. 1. The cam may be described roughly as a circular flange bent to 45-deg. angles at opposite sides of the propeller-shaft, thus forming four points 90 deg. apart on the flange.

This cam is enclosed in the housing seen in Fig. 2, which supports the shaft by two large ball-bearings. One block of nine cylinders is bolted to the front side of the cam housing and another to the rear side, making a total of 18 cylinders, arranged in a circle around the horizontal shaft, like the cartridge chambers in a revolver, as shown in Fig. 3. The cylinders are in pairs, one of each pair in either block, and each pair is served with one connecting-rod carrying a piston on each end. A pair of roller-bearings is mounted at the center of each connecting-rod, one rolling against each side or face of the cam, so that the connecting-rod assembly shuttles back and forth as the cam revolves.

Each cylinder-block also contains two ball-bearings to support the shaft. The gas mixture is introduced into a central chamber in each cylinder-block through the hollow shaft. The cylinders draw gas from this chamber and exhaust at the opposite, or outer, side. The power of the explosion above the piston drives the connecting-rod against the 45-deg. angle of the cam, thus imparting a rotary motion to the cam and propeller-shaft.

The cylinders are provided with oscillating sleeve-valves which are actuated by a set of cams mounted directly upon the propeller-shaft. The advantages of this arrangement are that the sleeves move with the abrupt acceleration of the poppet valve and remain stationary during the compression and explosion strokes, thus avoiding most of the difficulties encountered with poppet valves and sleeve valves of other types.

Because of the form of the power cam, the four-cycle operation of each cylinder is completed during each revolution of the cam. The firing order is in numerical rotation around each cylinder-block, with alternating explosions in the other block.

Ignition by Borrowed Fire

This arrangement makes possible a self-firing device having no additional mechanism or moving parts. This is accomplished by cutting ports through the sleeves and cylinder-walls above the top of the piston stroke and forming the cams to bring these ports into alignment at the right time to permit the fire in each exploding cylinder to ignite the compressed gases in the next following cylinder. This method of firing is not self-starting, nor does it eliminate the necessity of electrical ignition, which is supplied by two magnetos; but it has two distinct advantages: first, each cylinder will continue firing if a spark-plug becomes fouled, a connection is broken or a magneto fails after the engine has been started on the electrical spark; second, the electrical ignition can be cut out while sending or receiving a radio message from the air without interference from the magneto or spark-plugs, and the engine will continue running.

No springs, poppet valves or babbitt bearings are used in the construction of this engine. The elimination of such parts increases the durability and reliability. Oiling is by a gear-pump forcing oil to all parts requiring lubrication.

This engine is cooled by a circulating medium, which may be water or ethylene glycol, kept in circulation between the cylinder-walls and the radiator by an impeller-type pump. The radiator is composed of radial fins extending lengthwise of the engine in the form of a cylindrical sleeve of 17½-in. inside and 24-in. outside diameter, entirely surrounding the cam housing and cylinder-blocks. The cooling medium, being in constant circulation between the cylinder-walls and the radial fins, is cooled without leaving the engine, and the plumbing connections usual with detached radiators are eliminated.

All accessories are grouped on the rear plate as seen in Fig. 4, and come off in one assembly with it. With the front and rear plates removed, the engine is alike at both ends. The cylinder-blocks, cases, sleeve valves,

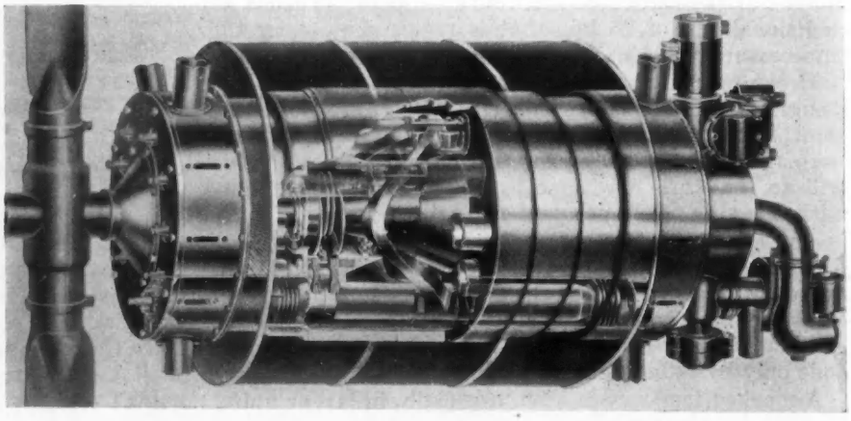


FIG. 3—PHANTOM DIAGRAM OF EARL AIRCRAFT-ENGINE

Two Cylinder-Blocks Contain Nine Cylinders Each. Each Piston-Rod Has Two Cam-Rollers and Carries Two Pistons. Each Cylinder Completes a Four-Stroke Cycle During One Engine Revolution. The Sleeve Valves Oscillate

cams and mechanism for actuating the valves are all interchangeable. The engine accessories are placed within reach of the pilot, for minor adjustments during flight and to allow unobstructed vision.

This engine weighs approximately 1 lb. per hp., which has been regarded as the ideal weight for an aircraft engine. The outside diameter of the radiator being only 24 in., the complete powerplant will fit in behind the dead portion of the propeller and cause no head-resistance, because the engine cowling will come within the natural streamlines of the front of the airplane. The propeller can turn at any desired speed, preferably 1000 r.p.m., which is regarded as the speed at which a correctly designed propeller will deliver the maximum pull. Therefore, this engine should deliver the maximum power to the craft on a given fuel consumption.

Since the public has taken to flying, there is an increasing demand for the elimination of propeller noise. A variable-pitch propeller, mounted on an engine developing sufficient power over a wide range of speed, can be adjusted as to speed and pitch to meet conditions while the plane is in the air. This will control propeller noise, make possible the delivery of the maximum pull under all conditions, and add considerably to the safety of flight.

As to durability, this engine is constructed of fewer moving parts or assemblies per cylinder than any other engine in use. The propeller-shaft assembly is one moving part; the connecting-rod assembly consists of three moving parts, the rod and two roller-bearings; and the sleeve assembly consists of two sleeves and two rocker-arms holding two rollers each. In the whole engine, exclusive of pumps and accessories, are only 178 moving parts, and all parts are built to stand rough usage. We believe that the cost of upkeep and operation of this engine will be below that of any other on record. Durability begets reliability, and reliability inspires public confidence in aviation.

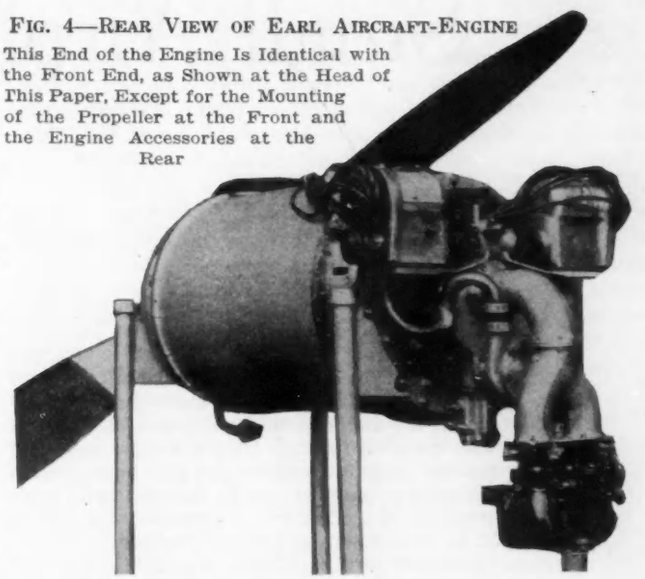


FIG. 4—REAR VIEW OF EARL AIRCRAFT-ENGINE
This End of the Engine Is Identical with the Front End, as Shown at the Head of This Paper, Except for the Mounting of the Propeller at the Front and the Engine Accessories at the Rear

Basing my judgment upon my own experience in mass production of automobile and aircraft engines, this engine can be manufactured and sold at a price per horsepower far below that of any other engine now in the aeronautic field.

Radio in Air-Transport Operation

(*Concluded from p.* 325)

of the wire beneath the covering as a result of gasoline and oil soaking through is one difficulty, while another is the inability to inspect and replace the wiring. Breakage of the cover, which is very fragile, is frequent even when extra care is taken in handling. A solid type of harness that is readily removable from the engine, and in which the wiring can be periodically inspected and renewed, is badly needed. A standard type of connection between the harness, the magnetos and the spark-plug shields should be agreed upon, as at present few are interchangeable. These matters are properly the responsibility of the engine manufacturers, to whom the final performance of the engines under actual flying conditions should be of vital interest.

The manufacturers of radio equipment, the Department of Commerce and the transport operators are doing everything in their power to make flying safer and more reliable by employing all known means of radio communication and navigation. In addition, more and more private owners of airplanes are looking toward radio as an added means of providing greater safety and more enjoyment in their flying. The one thing that is delaying progress at present is shielding against ignition interference. The responsibility for the future rests almost entirely with the manufacturers of engines and airplanes.

Flying an Airplane in Fog

(*Concluded from p.* 320)

the wind were strong, changing the localizer-beam direction would not be necessary. When flying in a fog, this direction should not be changed unless such a change is essential, as this constitutes another worry for the pilot who may be having difficulty enough without further complication. After getting on the localizer-beam, the procedure is exactly as mentioned before.

Although the results of these tests, which covered several months during which hundreds of blind landings were made without any breakage, showed conclusively that landing by instruments alone is possible, the procedure is still in a highly experimental stage. It now remains for some interested agency to continue the tests and develop this or some improved process to a commercially applicable stage. When this has been done, the airplane will become the safest known means of transport, as it will be the only one that can operate unhampered by fog.

Small Airplane-Engines

By N. N. Tilley[1]

Southern California Section Paper

Illustrated with Photographs and Drawings

WHILE the trend in aircraft-engine development has resulted in the production of airplane powerplants exceeding 100 hp. in many cases this has been accompanied by a demand for small engines ranging from 10 to 125 hp. At present the performance of small airplanes is at least twice as good as that of the training type of 10 years ago, resulting from a marked improvement in airplane construction and performance coupled with lighter and more modern powerplants. The speed ranges from 100 to 120 m.p.h. in level flight and in one instance a racing airplane equipped with a 135-hp. engine is reported to have attained 186 m.p.h. Small size of the powerplant and economical fuel consumption enable from 15 to 20 miles per gal. to be obtained.

Stating that the requirements of the airplane powerplant are light weight, low fuel and oil consumption, reliability and durability, smooth and flexible operation and compactness, the author discusses briefly how these are obtained. The greater proportionate weight of accessories, foundry limitations and other considerations than loads and stresses tend to make the small airplane-engine heavier in proportion to horsepower than the larger powerplants, manufacturing cost being more important than maximum performance in power and weight. The original small powerplant was a motorcycle engine which had only a short life as an aircraft engine. A fairly representative collection of illustrations of small powerplants supplements the paper, the structural differences being commented upon by the author.

Points brought out in the discussion include the securing of even distribution with a plain ring manifold, the advantages of cowling and of the inverted engine, the elimination of noise and reduction of the fire hazard.

THE TREND of aircraft-engine development has been toward larger and better engines, until at present there are airplanes with great power, in many cases exceeding 1000 hp. With the great increase of public interest in aviation during the last few years, a considerable demand for the small engine has arisen. Just what constitutes a small engine for an airplane is largely dependent upon the type of airplane for which it is intended. For power gliders, 10 to 15 hp. is considered ample; light airplanes seem to require 30 to 60 hp.; and a great number of civilian training or sport planes are available which have from 80 to 125 hp.

The airplanes that use small engines compare favorably in performance with those formerly available which had much larger powerplants. Considerable improvement in the construction and performance of airplanes has been made in the last 10 years, so that, with lighter and more modern powerplants, the performance of these small airplanes is at least twice as good as that of the training-type airplane at the end of the war. The landing speeds are generally below 40 m.p.h. Rates of climb are as high as 1000 ft. per min. Level-flight high-speeds generally range from 100 to 120 m.p.h. A racing airplane equipped with one of these small engines last year had a speed of 186 m.p.h. Because of the small size of the powerplant and since they are as economical in fuel consumption per horsepower-hour as the larger engines, 15 to 20 miles per gal. are readily obtained.

What Is Required of the Powerplant

Briefly, the requirements of the airplane powerplant are light weight, low rate of fuel and oil consumption, reliability and durability, smooth and flexible operation and compactness, so that the engine offers low resistance to speed through the air when combined with the airplane.

Light weight of powerplant and low rate of fuel consumption are essential to obtain the maximum disposable load. Also, considerable excess of power over that needed for flight is desired to enable the airplane to rise quickly from small fields, clear obstacles and obtain a safe altitude quickly. Light weight is obtained by compact arrangement, extensive use of aluminum alloys and high-strength steels and high power per unit of displacement. High power by high torque is desired, rather than high rotative-speed, to obtain best propeller-efficiencies. Small airplane-engines are likely to be relatively heavier than larger ones, because of the greater proportionate weight of accessories, foundry limitations on casting thicknesses and limitations of thickness of other parts by the possibility of flaws, fragility and other considerations than loads and stresses. In the small engine, maximum performance in power and weight are secondary to manufacturing costs.

Fuel and oil consumption for take-off should not exceed 0.60 lb. per hp-hr. with present airplane engines. For cruising, consumptions of slightly less than 0.50 lb. per hp-hr. can easily be obtained, especially if the mixture is leaned by automatic control while cruising.

The minimum reliability or freedom from forced stops, together with durability or life for non-military airplane-engines, is specified by the Department of Commerce, which issues an Approved Type Certificate for engines meeting the requirements. Most manufacturers strive to exceed these requirements so as to satisfy customers who observe no limitations of speed in power dives, who will use unsuitable grades of fuel and oil and who will abuse the engine in other ways. The customer desires an engine that will start as easily as his

[1] M.S.A.E.—Chief engineer, Kinner Airplane & Motor Corp., Glendale, Calif.

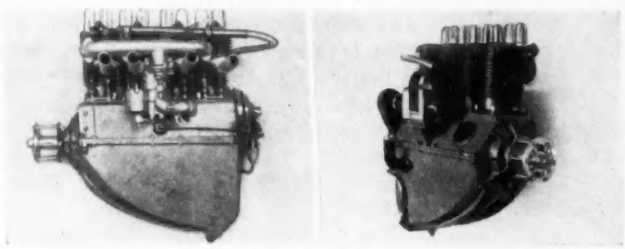


FIG. 1—SIDE AND THREE-QUARTER FRONT VIEWS OF THE HENDERSON-HEATH AIRPLANE ENGINE

In Its Essentials This Engine Is the Same as the Henderson Motorcycle Engine with Modifications To Incorporate a Propeller Drive and a New Lower Half Crankcase or Oil Sump. The Rating of the Engine Is 27 Hp. at 3000 R.P.M., and the Weight Including the Propeller Is 117 Lb.

automobile, give as little trouble and last as many years, or at least as many miles. The only comparison of reliability and life that I shall make herein is on the basis of whether the engine has obtained the Department of Commerce Approved Type Certificate. In this connection, it is interesting to note that virtually all new airplane-engines are air-cooled. The reliability of this type is somewhat better because of elimination of water leaks that occur with light-weight water connections and radiators. There is also the advantage that the weight is reduced about 0.50 to 0.75 lb. per hp. by eliminating this equipment.

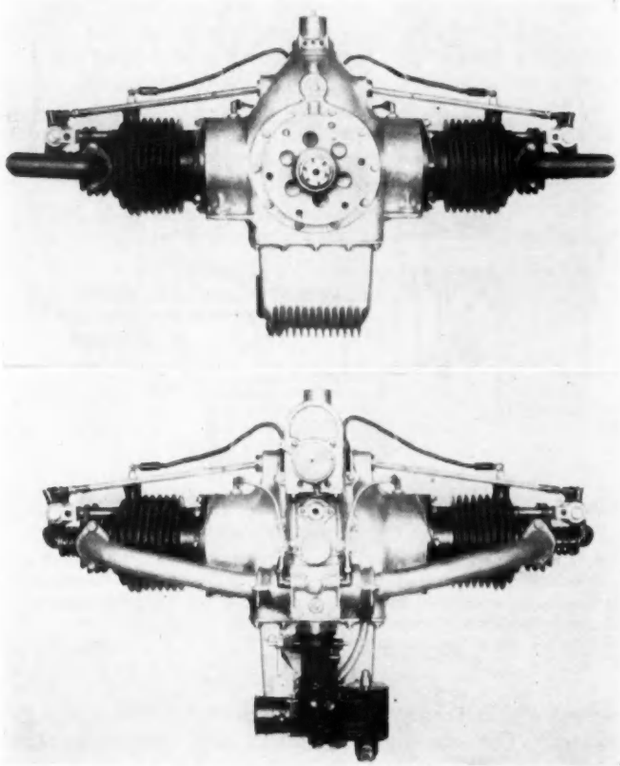


FIG. 2—FRONT AND REAR VIEWS OF THE MOREHOUSE ENGINE

Although Resembling a Motorcycle Engine, This Product of the Wright Aeronautical Corp. Is a Real Airplane Engine with Opposed Cranks, Forged Duralumin Connecting-Rods and High-Performance Cylinders. This Engine Weighs Approximately 90 Lb. and Develops 25 Hp. at 2500 R.P.M.

Smoothness of operation, that is, freedom from vibration, is necessary to avoid failures by fatigue in the structure of both powerplant and airplane, as well as to provide comfort for the pilot and passengers. Smoothness depends upon the dynamic balance, torque variation and the relative stiffness of the engine frame and the airplane supports for the engine. Adequate dynamic balance is readily attained in most cases. Torque variation is often overlooked. In some cases of large torque-variation, smoothness is obtained by high rotative-speed of the engine. Of course, an increased number of evenly spaced cylinders greatly reduces the torque variation. Suitable combinations of airplane and powerplant with respect to smoothness and freedom from vibration seem to be more a matter of trial and experience than of direct calculation.

Flexibility of operation facilitates control and includes, not only such factors as acceleration and deceleration and ready availability of power at any time, but also fine and quick adjustment of speed.

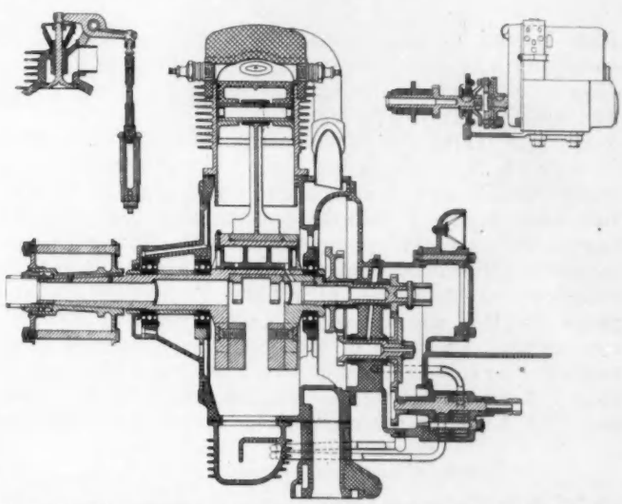


FIG. 3—LONGITUDINAL SECTION OF THE VELIE M-5 AIRCRAFT ENGINE

The Rating of This Engine Is 55 Hp. at 1815 R.P.M. and the Weight Is 223 Lb.

Compactness of the powerplant aids in making a lightweight powerplant. This favors a short stroke for the radial engine and a long one for the in-line air-cooled engine. However, the engine arrangement must be such as to avoid increasing the resistance to motion of the airplane and, therefore, the power required for its propulsion. The ideal arrangement would preserve the best stream-line shaped fuselage with no disturbance of the air due to the powerplant. Precise data on much of this phase are lacking, though a start has been made in the series of tests of the completely cowled radial engine described by the National Advisory Committee for Aeronautics reports.

Some Representative Examples

The illustrations show some of the structural differences in these small powerplants, the collection being fairly representative, although a number of engines have been omitted. Fig. 1 shows the Henderson motorcycle engine as rebuilt by the Heath Airplane Co., of Chicago, for its Parasol airplane. Basically, this engine is the same as the motorcycle powerplant with cast-

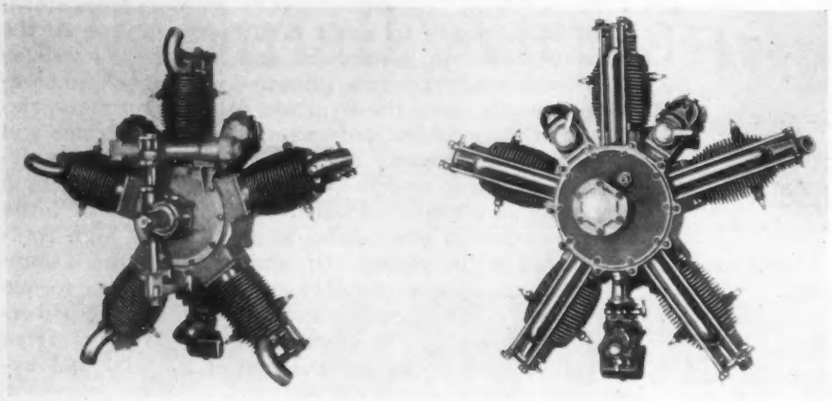


FIG. 4—FRONT AND REAR VIEWS OF THE SZEKELY 65-HP. FIVE-CYLINDER RADIAL ENGINE

In Addition to This Engine, Which Weighs 190 Lb., a Similar Engine with Three Cylinders and Developing 40 Hp. Is Built

iron L-head cylinders but has been modified to incorporate a propeller drive and a new lower half crankcase or oil sump. It is rated at 27 hp. at 3000 r.p.m., and weighs 117 lb., including the propeller.

Several years ago, Mr. Morehouse built the engine illustrated in Fig. 2 at his home. After completion of tests, the Wright Aeronautical Corp. obtained manufacturing rights. Although resembling a motorcycle engine, it is a real airplane engine with opposed cranks, forged duralumin connecting-rods and high-performance cylinders. J. A. Roché, of Wright Field, built an airplane for this engine, which made many flights with two people. Speaking of the accessory weight in small engines, the carbureter and single magneto weigh more than 1/6 the total weight of this engine, compared with less than 1/15 for large engines. Considerable trouble was experienced in starting this engine because of difficulty in cranking it fast enough for the magneto to give sparks. An impulse coupling from a truck engine enabled starting without difficulty. This engine weighs approximately 90 lb. and develops 25 hp. at 2500 r.p.m.

The Velie M-5 engine, illustrated in Fig. 3, has the accessories all in the rear. The aluminum cylinder-head is fastened to the cast-iron barrel by four long bolts. The crankshaft is of the two-piece type and is carried by three ball-bearings. The one-piece master rod has a plain big end, with the other connecting-rods held to it by link-pins. The weight of this engine is 223 lb. and the power output is 55 hp. at 1815 r.p.m.

Szekely makes two models, one with three cylinders, rated at 40 hp., and one with five cylinders, shown in Fig. 4, which is rated at 65 hp. at 1800 r.p.m. and weighs 190 lb. The oil pump and magneto drives are in front, with the magnetos between the cylinders. The one-piece cylinders are chromium-nickel cast-iron. The rocker-arm support carries both valve rockers on a single pin. The crankshaft is one piece and is supported by ball and roller-bearings. The auxiliary connecting-rods are of the slipper type, that is, the inner end has a foot held between the main bronze-backed babbitt-lined split bushing and split bronze rings in the master rod.

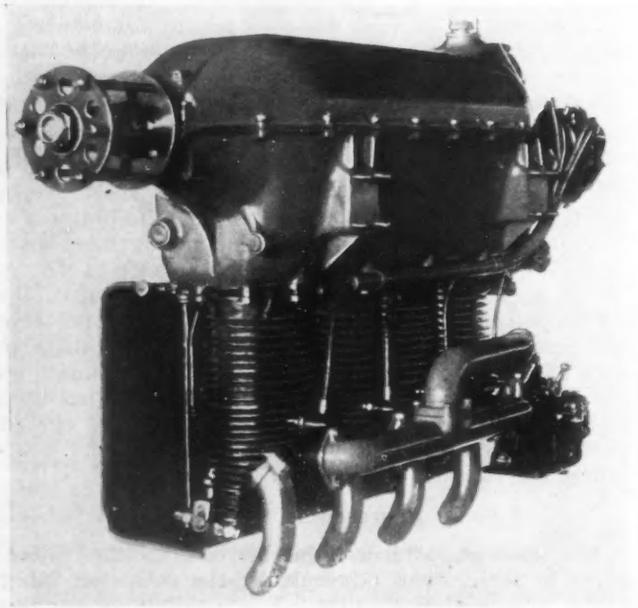


FIG. 5—THREE-QUARTER FRONT VIEW OF THE ROVER ENGINE

This Engine, Built by the Michigan Screw Co., Weighs 210 Lb. and Develops 60 Hp. at 1800 R.P.M. It Is an Inverted Four-Cylinder In-Line Engine with an Air-Scoop on the Exhaust Side of the Cylinders To Assure Transverse Air-Flow

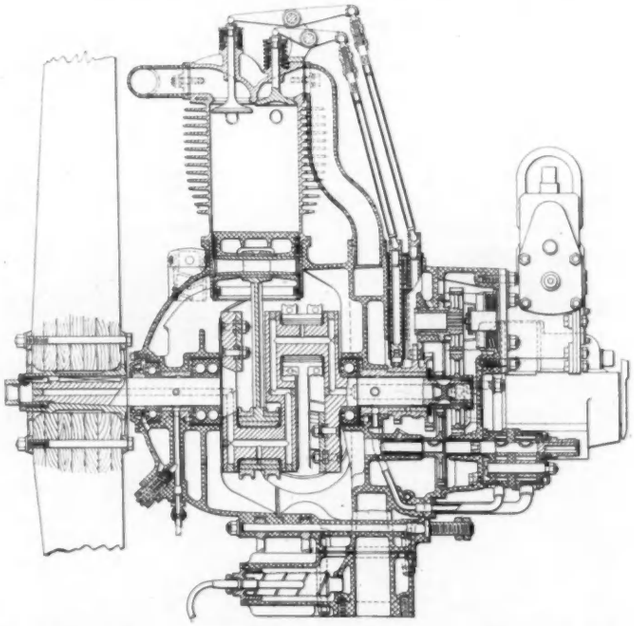


FIG. 6—LONGITUDINAL SECTION OF THE BROWNBACH SIX-CYLINDER ENGINE

The Use of a Two-Throw Crankshaft Makes This Engine Really a Double Three-Cylinder Type, Leaving Only the Longitudinal Moment between the Two Crankpins for the Counterweights To Balance as One Group of Cylinders Balances the Other. The Rating of This Engine Is 80 Hp. at 1700 R.P.M. and the Weight Is 260 Lb.

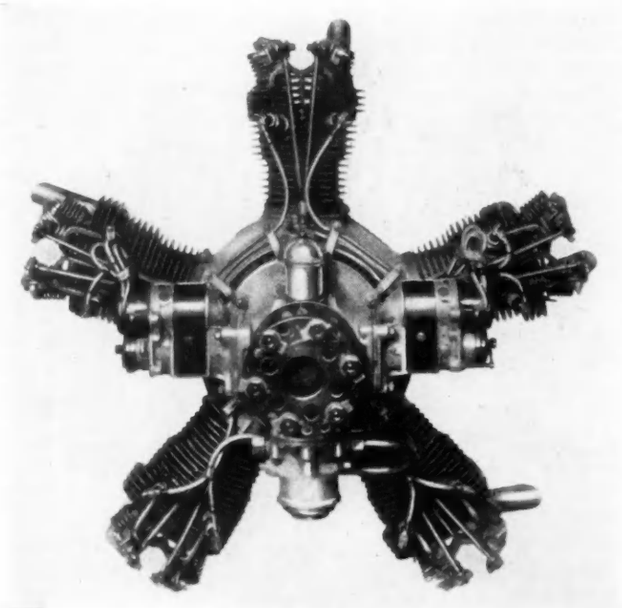


FIG. 7—THE 88-HP. GENET ENGINE

An Interesting Feature of This Engine, Which Weighs 215 Lb., Is the Location of the Accessories Mostly in Front

Fig. 5 shows another engine designed by Morehouse, the Rover, built by the Michigan Screw Co. It weighs 210 lb. and develops 60 hp. at 1800 r.p.m. This is an inverted four-cylinder in-line engine, with an air scoop on the exhaust side of the cylinders to assure transverse air-flow across the cylinders. This engine has all accessories in the rear, the starter being at the top with two magnetos, one of which is equipped with an impulse coupling, and the oil-pumps underneath and the carbureter at the bottom. The cylinders are of chromium-nickel cast-iron. The connecting-rods are of forged duralumin.

The Brownbach C-400, illustrated in Fig. 6, is a development from the Anzani engines. It is a six-cylinder radial with a two-throw crankshaft, that is, a double three-cylinder engine, rated at 80 hp. at 1700 r.p.m. and weighing 260 lb. The two-throw crankshaft permits one group of cylinders to balance the other so that the counterweights need balance only the longitudinal moment between the two crankpins. The auxiliary connecting-rods are of the slipper type. The cylinders are of nickel cast-iron held to the crankcase by two long bolts.

Fig. 7 shows the British Armstrong Siddeley Genet engine, which is reported to be made by Fairchild and is approved for license without a Department of Commerce certificate. It is rated at 88 hp. at 2400 r.p.m. and weighs 215 lb. This engine has many interesting details of construction, among which is the location of the accessories mostly in front. The aluminum cylinder-head is screwed in a steel barrel. The lowest head-fin is a steel lock-nut. The barrel screws into the crankcase, where another clamp or lock-ring is located. Changing the compression ratio of this engine is said to be easy. In the rear is a fan that runs at crankshaft speed, giving rotary distribution.

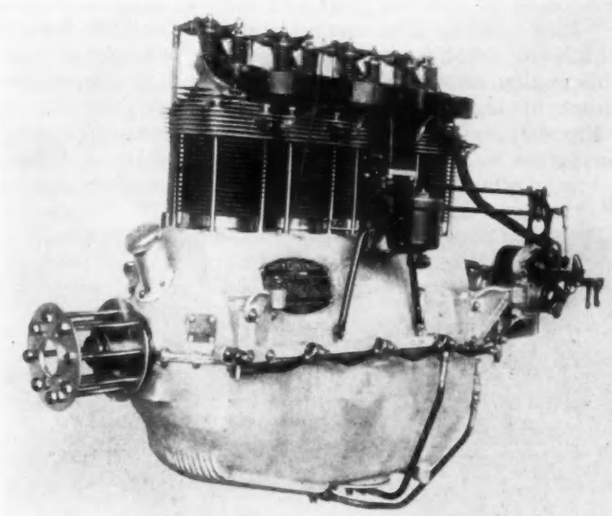


FIG. 9—THE 90-HP. GIPSY ENGINE

This Product of the Wright Aeronautical Corp. Weighs Approximately 280 Lb. One of These Engines in a Small Racing Airplane Developed about 135 Hp. and Is Reported To Have Driven the Airplane at 186 M.P.H. in Level Flight

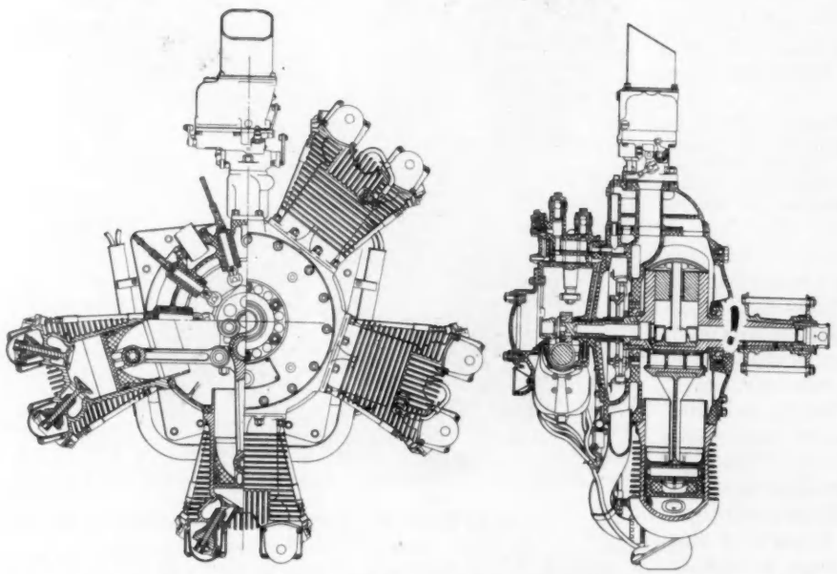


FIG. 8—SECTIONAL VIEWS OF THE LE BLOND 60-HP. ENGINE

In Addition to This Engine That Weighs 222 Lb., Another with Seven Cylinders, Which Develops 90 Hp. at 2000 R.P.M. and Weighs 285 Lb., Is also Built

The five-cylinder Le Blond engine, Fig. 8, develops 60 hp. at 1900 r.p.m. and weighs 222 lb. A seven-cylinder model that develops 90 hp. at 2000 r.p.m. and weighs 285 lb. is also built. The one-piece cylinders are of nickel-chromium cast-iron, fastened to the crankcase with short studs. The one-piece crankshaft is supported by only two ball-bearings. The auxiliary connecting-rod link-pins are located by the master-rod cap-bolts. All accessories are to the rear of the engine, and

the drives for the various accessories are all combined in a single unit-assembly.

Speed of 186 M.P.H. with 135 Hp.

The Cirrus, a four-cylinder in-line air-cooled engine, has made an excellent showing in Europe and is now being built in the United States. A similar engine is the British Gipsy, which is slightly larger. Both engines are approved by the Department of Commerce for license without type certificates. A small racing airplane with the Gipsy engine is reported to have a speed of 186 m.p.h. in level flight. The racing engine developed about 135 hp., but the standard type is rated at 95 hp. at 2100 r.p.m. and weighs approximately 280 lb. The Gipsy engine has aluminum heads and cast-iron barrels that are held to the crankcase by long studs. The connecting-rods are of forged aluminum. The crankcase is of the wet sump type. This engine, shown in Fig. 9, is to be built in the United States by the Wright Aeronautical Corp.

Fig. 10 shows the very familiar training engine used during the war, the Curtiss OX-5, installed in a Curtiss-Robin airplane, which with three passengers has a high speed of 100 m.p.h., an initial climb of 400 ft. per min. and a ceiling of approximately 13,000 ft. This engine develops 90 hp. at 1500 r.p.m. and weighs 375 lb. dry and about 450 lb. when ready for service, or 5 lb. per hp. as compared with 3 lb. or less for other engines described in this paper. The Robin airplane has a much higher speed and carries more load than the familiar wartime training airplane, the Curtiss JN-4D, and represents in some respects the advance that has been made in airplane design. Substituting a lighter engine for the OX-5 necessitates mounting the engine considerably farther from the wings to maintain proper weight balance of the airplane. Generally a second person can be carried or the rate of climb of the airplane is considerably increased.

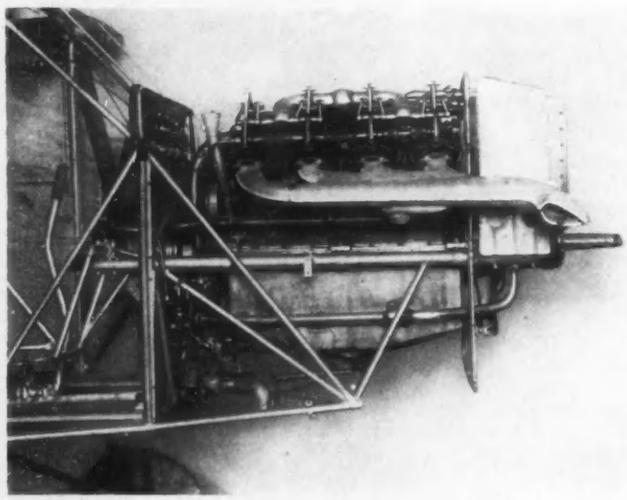


FIG. 10—A CURTISS OX-5 90-HP. ENGINE INSTALLED IN A CURTISS ROBIN AIRPLANE

This Airplane, with Three Passengers, Had a Maximum Speed of 100 M.P.H., an Initial Climb of 400 Ft. per Min. and a Ceiling of Approximately 13,000 Ft. The Engine Has a Dry Weight of 375 Lb. and Approximately 75 Lb. More When Ready for Flight, Giving a Weight of 5 Lb. per Hp. as Compared with 3 Lb. or Less for Other Engines

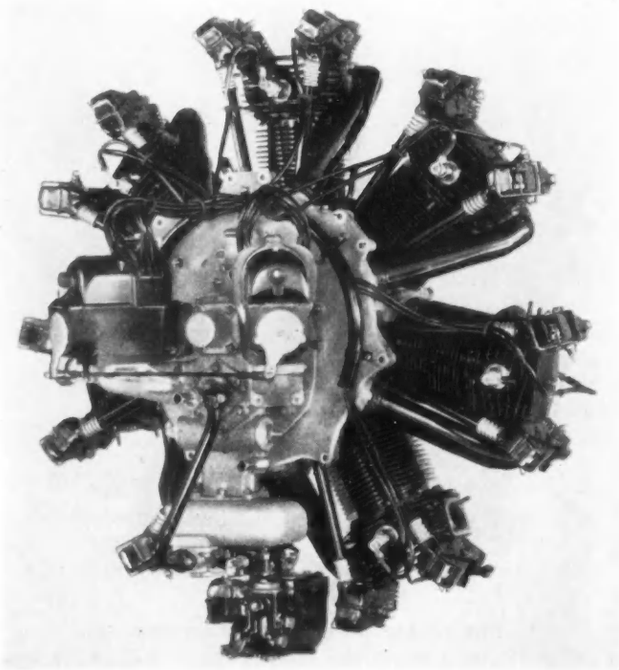


FIG. 11—THE WARNER SCARAB SEVEN-CYLINDER RADIAL ENGINE

In Construction This Approaches the Compactness of the Military Type. It Develops 110 Hp. at 1850 R.P.M. and Weighs 270 Lb.

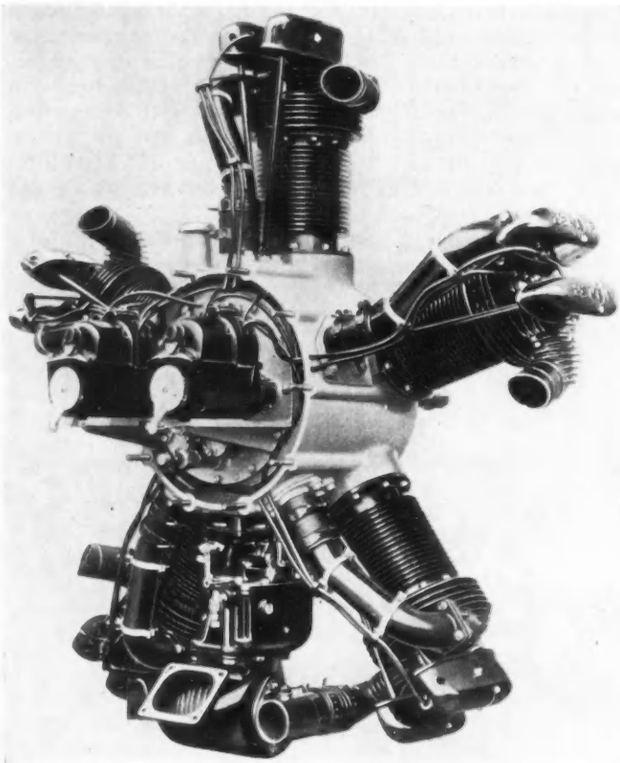


FIG. 12—THREE-QUARTER REAR VIEW OF THE KINNER ENGINE

A Feature of the Construction Is the Operation of the Valves by Individual Camshafts for Each Cylinder Instead of the Conventional Cam Rings. The Rating Is 110 Hp. at 1825 R.P.M. and the Weight, Including Air Heater and Exhaust Stacks but No Propeller Hub, Is 280 Lb.

Fig. 11 shows the Warner Scarab, a compact seven-cylinder radial engine built much like the military types. Some of its features are the aluminum head, shrunk and fastened to a steel cylinder-barrel with short studs; crankcase split on the center line of the cylinders; and a one-piece crankshaft with ball and roller thrust and main bearings. This engine is rated at 110 hp. at 1850 r.p.m. and weighs 270 lb. when ready for service.

Fig. 12 is a three-quarter rear view of the Kinner engine. It has an aluminum cylinder-head fastened to the flanged upper end of the steel cylinder-barrel by short studs. The valves are operated by individual camshafts for each cylinder instead of the conventional cam rings. The crankshaft is in one piece. All bearings are plain bearings, except the ball thrust-bearing located next to the crank cheek. The manufacturer's rating is 110 hp. at 1825 r.p.m. As shown, the weight is 280 lb., which includes air heater and exhaust stacks, but no propeller hub.

THE DISCUSSION

CHAIRMAN LEIGH M. GRIFFITH[2]:—Will Mr. Tilley comment on the difficulty experienced in getting an even distribution with a plain ring manifold without any distribution fans?

N. N. TILLEY:—Mr. Kinner had solved that problem before I came on the job and apparently he did it very well, as the distribution seems to be remarkably uniform. I have watched other engines with ring manifolds. In those having nine cylinders, three manifolds are connected to a three-barrel carbureter, making in effect three engines so that three cylinders would function alike. In the five and seven-cylinder types, a ring manifold with a carbureter at the bottom can be used and fairly uniform distribution secured. Most designers taper their manifolds. Some bring a carbureter in at the side and some at the bottom. Fair success is secured with either method.

JOHN L. WEISEL[3]:—What was the compression ratio of the Gipsy engine used in the 180-m.p.h. racing airplane?

MR. TILLEY:—I do not recall, but I would guess that it was about 7 or 7½ to 1. That engine was using special fuel.

In-Line Engines

F. M. JENKINS[4]:—Why was not the development of the inverted in-line engine carried farther than it was?

MR. TILLEY:—The advantage claimed for this type is that you can get the high thrust line that the airplane people like and still have good visibility. The Government is pushing an inverted 12-cylinder engine, and some of these engines are in use in airplanes. The idea is to use the Vee to catch cooling air and let it go out sideways between the cylinders. The object of this development is to provide better visibility than is obtained with radial engines. Pilots like the inverted engine because the exhaust goes below the airplane and they are relieved from the gassing and noise. Apparently no particular difficulty is experienced in making such an engine. The skirts of the cylinders project into the case, which leaves an oil sump. When the engine is up to speed, all the oil is thrown out on the crankcase and then drains down. With the water-cooled inverted Liberty engine, the advantage seemed to be chiefly in the amphibian type, and, in fact, that is what originally made the Loening amphibian.

J. J. MURRAY[5]:—Is the relative difference in the frontal area of an in-line engine with the scoops as compared with a well streamlined radial engine very great?

MR. TILLEY:—The former has a considerably smaller frontal area than any of the radial engines, which, of course, differ greatly, depending on the number of cylinders. With seven or more cylinders, the engine can be totally surrounded by cowling. With the smaller number of cylinders, whether or not the totally cowled engine will be useful still has to be demonstrated.

Mufflers and Fire Risk

JOHN WIGGERS[6]:—Is any attempt being made to put mufflers on airplane engines?

MR. TILLEY:—At the Army Experimental Division a muffler was developed which seemed to be very effective. We thought all the pilots would like it very much, as it eliminated a great deal of the noise. The sound was so different that they did not like to fly that ship, and weeks elapsed before they became accustomed to not having the noise. When the pilots began to like the mufflers, the people working on reduction of fire risk came along and said mufflers were a terrible fire risk. These people had motion pictures taken of crashes; that is, they had rigged up an arrangement whereby an old engine and fuselage would crash into a concrete wall. They obtained some evidence indicating that the fires all started from the iron exhaust stacks. So mufflers were in disfavor. The power-plant engineers then endeavored to make the exhaust stacks run cooler than about 1200 deg. fahr. By using aluminum, the stack temperatures were reduced to 500 or 600 deg. fahr., about the same as the air-cooled heads.

For radial engines, connecting the cylinders into an exhaust ring and passing the exhaust out at the bottom relieves the people in the airplane. Some engine manufacturers have exhaust rings as standard equipment. The weight of the engine all depends on what one includes in the engine weight. Part of present light weights is secured by including exhaust stacks as part of the airplane equipment instead of part of the engine. There should be no back pressure, which decreases the power. In the case of very high-speed engines with metal propellers, the propeller makes far more noise than the exhaust, so the exhaust noise can be eliminated and still leave considerable noise. The noise of military pursuit airplanes is propeller and not engine noise. That can be demonstrated by propeller tests; the propeller can be heard for miles, but the engines can be

(*Concluded on p.* 371)

[2] M.S.A.E.—Vice-president and general manager, Emsco Aero Engine Co., Bell, Calif.

[3] Engineer, Menasco Motors, Inc., Los Angeles.

[4] Assistant garage superintendent, Blue Diamond Co., Los Angeles.

[5] M.S.A.E.—President, Aircraft Holding Corp., Culver City, Calif.

[6] M.S.A.E.—Chief engineer, Moreland Motor Truck Co., Burbank, Calif.

Front-Wheel Drives

By P. M. Heldt[1]

Milwaukee and New England Sections Paper — *Illustrated with* Photographs and Drawings

ENGINEERING considerations leading to the former almost universal practice of steering with the front wheels and driving and braking with the rear wheels are reviewed, and the desire for bodies lower than can be made with conventional design is given as the main reason for the present interest in front drives. For early history, European development, racing practice and the closely related subject of four-wheel drives, the reader is referred to a previous paper by Herbert Chase.[2]

One major advantage to be secured with front-drive design is lower unsprung weight, which should promote easy riding and road-holding ability and reduce tire wear. An inherent disadvantage is that driving-torque reaction and hill climbing shift some weight from the front axle to the rear axle, thus slightly reducing the tractive effort possible; but this shift is not considered important, since the control of weight distribution is in the hands of the designer.

The chief difficulties of design have been in finding an arrangement that keeps down the hood length and in providing for the location of a sufficiently large radiator and the driving of the radiator fan.

Much of the discussion, both at the Milwaukee and the New England Section meetings, was about the comparative danger from front-wheel and rear-wheel skidding and the difficulty of overcoming skidding. Universal-joints also were discussed. Among the other subjects discussed at Milwaukee were independent springing of front wheels and tire wear, while some early traction tests on electric vehicles were reported in Boston.

UP TO A FEW years ago, virtually all passenger-cars as well as commercial vehicles were driven by their rear wheels, but during the last two years considerable interest has been manifested in vehicles with front-wheel drive. Motor-vehicles can be driven by the rear wheels, the front wheels or all four wheels, and in looking for the reasons for the present interest in front drive it is well to start by considering the reasons that led to the adoption of the rear drive in the first place.

Aside from supporting the weight of the vehicle, the wheels serve three different functions: those of steering, driving and braking. All of these functions can be accomplished through all four wheels, but considerations of simplicity and economy made it desirable to accomplish each function through one pair of wheels, either front or rear. Steering by the front wheels is far more practical than steering by the rear wheels, because a car with rear-wheel steering, if parked very close to a curb, can get away only by backing; therefore, front steering was adopted from the first. The drive was effected through the rear wheels because it is easier and simpler to drive the non-steering than the steering wheels. Braking was done on the rear wheels for a similar reason.

Front drive was used to a very limited extent on fire apparatus converted from horse to power propulsion by the substitution of a two-wheeled motor fore-carriage for the original front-axle and bolster, on low-platform trucks used for the transportation of horses, and on other vehicles for special purposes. If we disregard these comparatively unimportant applications and the use of four-wheel drive on Army trucks and vehicles for cross-country service, we can say that rear driving was used exclusively up to very recently.

For many years there has been a tendency to lower the center of gravity of passenger vehicles to increase their stability at high speeds. Underslung springs, double-drop frames and small-diameter wheels were among the expedients for bringing the frame and the body floor closer to the ground. Finally, interference of the floor of the passenger compartment with the propeller-shaft set a limit. In Europe, many small cars are being built with a so-called tunnel for the propeller-shaft at the middle of the floor of the passenger compartment, but this is objectionable on grounds of both appearance and convenience and has never found favor with American designers.

Propeller-Shaft Limits Floor Level

The demand for still lower floors than are permissible with the ordinary spiral-bevel-gear drive led to the development of the hypoid-gear drive and the reintroduction in this Country of worm-gear drive, undermounted, for passenger-cars. With both of these drives, the rear end of the propeller-shaft is below the axis of the rear axle, and the body floor can be further lowered without interference with the propeller-shaft. However, it became apparent that, if the tendency toward lower construction continued, the margin made available by the adoption of these drives would soon be taken up, and engineers then began to think of eliminating the longitudinal propeller-shaft at the middle of the car, which was the cause of this limitation. The front drive possesses certain other advantages, but there can be little doubt that the chief motive behind the movement toward front drive for passenger-cars that set in about two years ago was the desire to place the body floor lower than was practicable with a propeller-shaft to the rear.

With rear-wheel drive and a powerplant located at the forward end of the car, the differential and the final-reduction gear are usually incorporated in the rear axle. Owing to the action of the chassis springs, a certain

[1] M.S.A.E.—Engineering editor, *Automotive Industries*, Philadelphia.

[2] See S.A.E. Journal, September, 1928, p. 249; and Transactions, vol. 23, 1928, part 2, p. 267.

amount of vertical motion between the chassis frame and the driving wheels must be allowed for in transmitting the power to the wheels. To compensate for this relative motion is easier in a propeller-shaft extending lengthwise of the car than in the driveshafts between the differential and the driving wheels; therefore, the pioneer automobile engineers followed the line of least resistance by incorporating the differential and driving gear in the rear axle. In recent years, however, some European designers have broken away from this practice by mounting the differential and driving

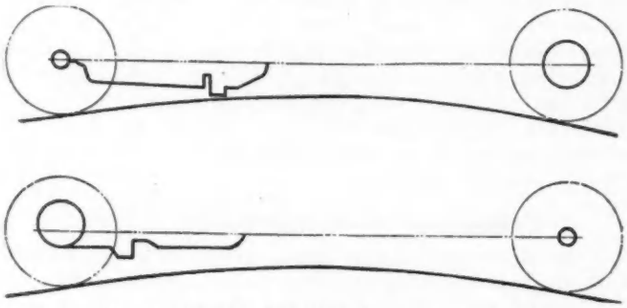


FIG. 1—ADVANTAGE OF FORWARD LOCATION FOR FLYWHEEL

gear on the chassis frame and driving the wheels through shafts capable of swinging in a plane perpendicular to the length of the car.

Length Presents a Difficult Problem

Drive conditions are different with front drive and a powerplant located at the forward end of the car. The engine, clutch, transmission and final-drive gear usually are combined in one unit or block. The axis of the final-drive gear must lie in the vertical plane through the steering-pivot axes, or at least close to it, and the engine can be either forward or back of the driving gear. However, the only practical arrangement for passenger-cars seems to be to place the engine back of the axle, as this results in a car of the conventional form.

Difficulties of front-wheel-drive designers have been increased by the fact that the advent of front-wheel drive for passenger-cars has occurred during a period when the vertical type of eight-cylinder engine is enjoying great popularity and four-speed transmissions are gaining favor; for one of the greatest problems that confronts the designer is that of keeping down the length of the hood required to cover the powerplant, which roughly measures the distance from the front axle to the dash. With the length of body space fixed, any addition to the distance between the front axle and the dash calls for an increase in the wheelbase. Abnormally long wheelbases are undesirable, because they add to the necessary frame weight and also reduce the maneuverability of the vehicle—an important consideration in these days of traffic congestion.

Advantage in Ground Clearance

When a lowering of the car frame and floor is considered, the problem of ground clearance arises. A certain amount of ground clearance is needed so that the lowest parts of a car shall not hit rocks projecting above the road surface or scrape on ridges between ruts. However, the location of the lowest point of the chassis is a matter of some importance, and the front-drive car has a certain advantage in this, as illustrated by Fig. 1. Usually the lowest point of the chassis is the bottom of the flywheel housing. Conditions with respect to road clearance may become critical when a car, particularly one with a long wheelbase, passes over the brow of a hill. In a rear-drive car having a multi-cylinder vertical engine, the flywheel housing is not far from midway between the front and rear wheels, and the clearance may be entirely taken up if the top of the hill is sufficiently sharp. The flywheel housing of a front-drive car is much nearer the front axle, and the clearance is not affected so much.

Riding-Qualities Are Improved

At this point it is opportune to refer to another important advantage of front-driving, that of improving the riding-qualities of a car. I desire to emphasize that this comparison is between two cars that are alike in every respect except the location of the drive; I do not want to express the opinion that any car with front drive must of necessity have better riding-qualities than any car with rear drive. The reason for the improvement in riding-qualities with the adoption of front drive is that the unsprung weight is reduced. It is well known that the smaller the unsprung weight is in proportion to the sprung weight, the greater is the riding comfort, other things being equal.

Riding comfort is affected most by the rear axle, as the rear seat is almost directly over it. A plain dead axle can be made to weigh much less than a live axle comprising separate carrying and driving members, together with a differential. To reduce the weight to the minimum, the rear axle in one case was made of thin-walled heat-treated chromium-molybdenum tubing, such as is used largely for airplane structures and for the front axles of two well-known makes of passenger-car. Whether such high-grade stock will come into general use for the purpose is questionable, for one

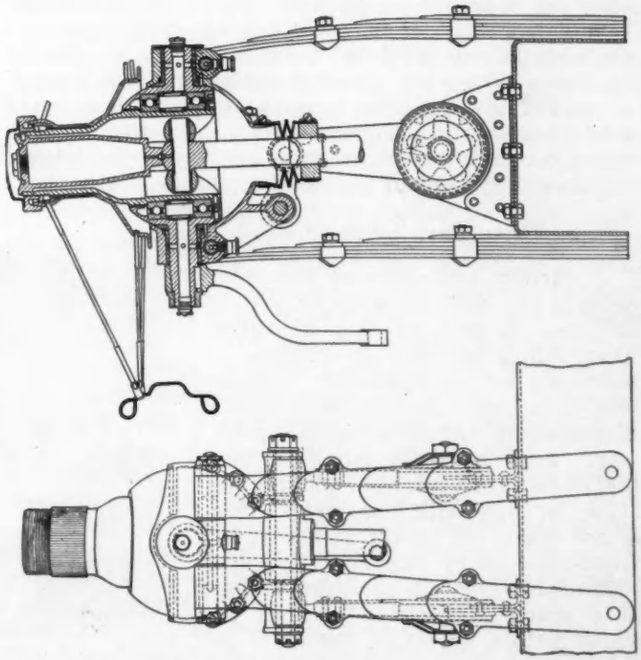


FIG. 2—FRONT DRIVE AND SPRING SUSPENSION OF ALVIS CAR
Shock-Absorbers Are Built In. The Lower View Is the Plan

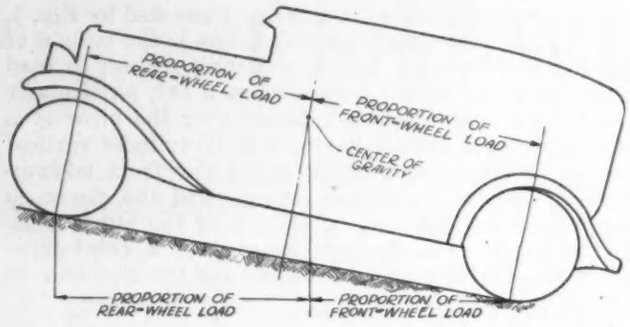


FIG. 3—TRANSFER OF CAR WEIGHT ON GRADE

reason because the thin-walled tube deforms easily if a jack is applied to it. The jack is naturally placed under the forged end of the tubular front axle, while accessibility tempts the operator to place the jack under the central tubular part of a cranked rear axle. But even made from ordinary seamless-steel tubing or as a drop-forged I-section, the dead rear axle is much lighter than a live axle of equal capacity.

This reduction in the unsprung weight at the rear is not accompanied by a similar increase in unsprung weight in front, for the differential and driving gear, which are removed from the rear axle, are not placed on the front axle but are mounted on the chassis frame and therefore are spring-suspended. It is even possible to reduce the unsprung weight at the front, as compared with a rear-drive car of equal total weight. Although the proportion of weight on the front axle is likely to be greater in the case of the front-drive car, and the front axle therefore must be somewhat stronger, the front brakes can be removed from the wheels and located on opposite sides of the driving-gear housing, thus making them a part of the spring-supported weight.

The reduction of unsprung weight resulting from the adoption of front-driving should also result in a reduction of tire wear. If the axles and wheels are light and the chassis supported by them is heavy, the chassis springs will keep the wheels in contact with the ground, instead of allowing them to bounce into the air at every road irregularity. This will prevent the tire slippage which occurs when contact with the road is established again, which is one of the greatest causes of tire wear.

Front-Drive Cars Cling to Road

A further advantage of the front drive is that vehicles equipped with it are less inclined to skid at turns. That this holds true in practice is borne out by the testimony of those who have had experience with front-drive cars on the Indianapolis Speedway. It is generally admitted that higher speeds can be maintained safely on turns with front drive. This is not disproved by the fact that no front-drive entry has ever won the Indianapolis 500-mile race, for success in a speed competition depends on many factors, of which the drive is only one.

The theoretical reason for the better road-holding ability of the front-drive vehicle on turns is probably as follows: Slewing is greatly promoted by the slipping of the rear wheels on the ground in the direction of their planes. Such slipping of the rear wheels in the case of a conventional car is easily induced by locking the rear brakes, and every experienced driver knows that he must not apply his brakes in such a way as to lock the wheels when proceeding on slippery surfaces. Once the wheels are locked and slide over the ground, they slide sideways as easily as in the direction of their planes, and the least inequality in the resistance to motion at the two sides starts a skid. In making a turn under power, the rear wheels will certainly run with less slippage if they are not driven than when they are being driven, hence they have greater ability to hold the vehicle to its course in the case of a front-drive car. The lower unsprung weight on the rear wheels also tends to make them hold the road better and to prevent skidding.

Independent Springing for Front Wheels

Front-drive cars can be built either with or without a front axle. American firms that have gone in for front drive so far have adopted the axle, while European firms usually omit this component and employ independent suspension of the front wheels. The steering heads or axle ends may be carried at the ends of leaf springs or links extending laterally from the drive-gear housing, or the steering-knuckles may be arranged to slide on vertical studs secured to the chassis frame or body, being cushioned on coiled springs. One British construction is shown in Fig. 2. If a rigid axle-center is to be used, it is, of course, impossible to carry it

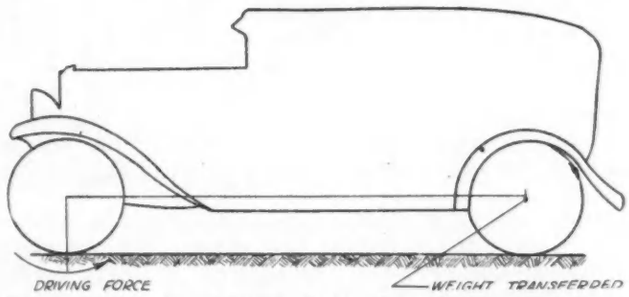


FIG. 4—EFFECT OF TORQUE REACTION ON WEIGHT DISTRIBUTION

FIG. 5—MOTORCOACH OF THE BERLIN GENERAL OMNIBUS CO.

straight across from steering-knuckle to steering-knuckle, as the drive-gear housing interferes. The axle can be cranked or curved to pass over, under or in front of the drive-gear housing, and two of these three positions have been used in the two front-drive cars made in America.

Traction Conditions Are Less Favorable

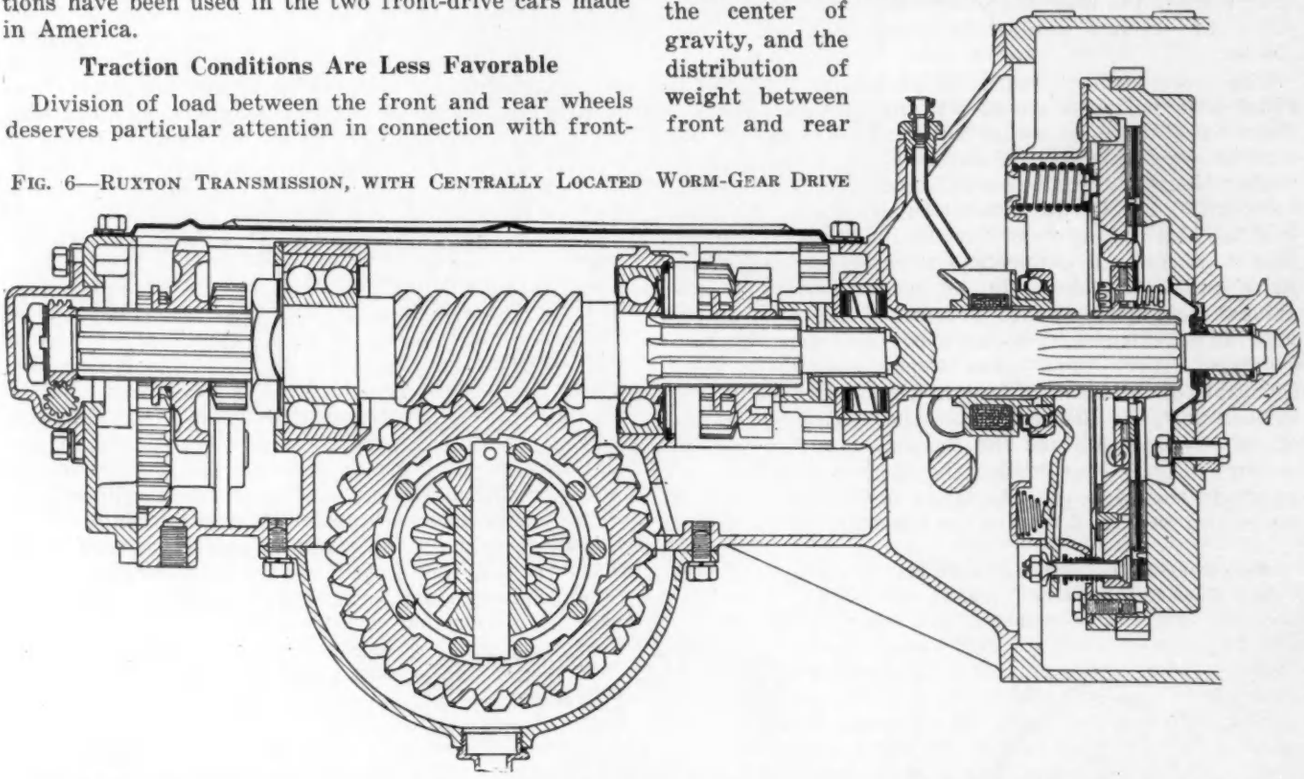
Division of load between the front and rear wheels deserves particular attention in connection with front-drive vehicles, since the maximum traction available in a motor-vehicle is directly proportional to the weight on its driving wheels. The four-wheel drive is chosen for vehicles such as Ordnance Department trucks, which must operate under particularly unfavorable traction conditions. In ordinary commercial trucks the designers aim to place at least 80 per cent of the total weight on the rear driving-wheels under conditions of full load. In passenger-cars, lack of sufficient load on the traction wheels has caused no difficulty in the past, because passenger-cars normally work under less severe conditions than do trucks from this point of view and, in the rather rare case of stalling for lack of sufficient traction, a little assistance from willing hands helps remarkably.

But conditions affecting the limiting traction are rather more favorable with the rear-wheel than with the front-wheel drive. When a normal passenger-car is loaded, the weight on the rear driving-wheels is usually considerably greater than that on the front steering wheels. On an upgrade, where more traction is required, additional weight is transferred to the drivers in the case of the rear-drive car, whereas with the front-drive car some of the weight is removed from the drivers by the inclination of the vehicle. Moreover, the reaction to the driving-wheel torque also adds to the weight on the drive wheels in the case of rear drive and subtracts from it in the case of front drive. Therefore it is plain that, with the same weight distribution and the same tire treads and road surfaces, the maximum traction is greater in a rear-drive than in a front-drive car.

Torque and Grade Affect Weight Distribution

The condition of weight transfer by an up-grade is illustrated diagrammatically in Fig. 3. The weight of the car and load may be considered as concentrated at the center of gravity, and the distribution of weight between front and rear wheels is then in inverse proportion to the horizontal distances between the center of gravity and the points of ground contact of the front and rear wheels respectively. In the drawing the proportions are so chosen that the center of gravity is midway between the points of ground contact of the front and rear wheels when the car stands on the level. On a 30-per cent grade, as shown, the vertical line through the center of gravity is much closer to the point of ground contact of the rear wheels than that of the front wheels, hence the rear wheels carry more weight.

FIG. 6—RUXTON TRANSMISSION, WITH CENTRALLY LOCATED WORM-GEAR DRIVE



In Fig. 4 the circumferential force on the front driving-wheel is represented by a circular arc with arrowhead. When the front driving-wheels are developing a certain torque, the chassis frame is subjected to an equal torque in the reverse direction, referred to as the torque reaction. The effect of this reaction is to press the rear wheels more forcibly against the ground, or, in other words, to add to the load on these wheels. Since the total load remains the same, it is obvious that the load on the front wheels is correspondingly reduced.

This difference in the limiting traction is of no consequence under ordinary driving conditions on hard-surfaced, dry roads, as the traction is sufficient to meet the requirements in both cases. Probably the characteristic referred to assumes its most serious aspect when considering starts from traffic stops on greasy pavements. The actual importance of the matter can be determined only by experience. It is hardly necessary to point out that front-drive designers have it within their power to improve conditions in this re-

spect. They are not constrained to use the same weight distribution as is customary in rear-wheel-drive cars. Moreover, the transfer of weight due to torque reaction is considerable only when accelerating in low gear. Lengthening the wheelbase decreases it, and long wheelbases are rather natural in connection with front drives.

The powerplant ordinarily is placed in front of the front axle in motor-trucks and motorcoaches having front-wheel drive, to obtain a more favorable distribution of weight between front and rear wheels and a higher limiting torque. An example of this is the motorcoach of the Berlin General Omnibus Co., shown in Fig. 5. This arrangement has the incidental advantage that it makes the powerplant more accessible for repairs and replacement; but it would hardly be considered for passenger-cars, because of the effect on the general appearance. Designers of front-drive passenger-cars already have taken steps to obtain a more favorable distribution of weight than prevailed in the earliest designs. In the Ruxton, the final-drive gear is placed at the center of the transmission housing, as shown in Fig. 6, thus moving the whole powerplant forward. In the Alvis car, the wheel mountings of which are shown in Fig. 2, the entire transmission is placed in front of the front axle. As seen in Fig. 7, no direct drive is provided.

While the chief incentive of the designer in adopting these arrangements may have been to reduce the length of hood required, they also add to the proportion of the weight on the front axle. Another feature of the Ruxton car tending in the same direction is the location of the storage-battery forward, alongside the engine, instead of under the front floor-boards. The Cord also carries the storage-battery under the hood, as shown in Fig. 8. Other illustrations of the Ruxton[3] and Cord[4] cars will be found in the descriptions in various trade papers.

Problems in Designing Front Axle

As has already been pointed out, it is unnecessary, with front-wheel drives, to carry the front brakes on the wheels; their drums can be mounted on the short shafts of the differential side-gears, as in the Cord car. Removing the brakes from the wheels eliminates what is probably the principal factor in front-wheel shimmy. Without brakes, the natural period of oscillation of the front axle is substantially reduced, and for otherwise similar conditions shimmy can occur only at higher car-speeds, which may be outside the driving range. The tendency to shimmy and tramp is greatly reduced if no brakes are mounted directly on the front wheels.

Front-driving confronts the automobile designer

[3] See *Automotive Industries*, June 29, 1929, p. 974.

[4] See *Automotive Industries*, Aug. 31, 1929, p. 298.

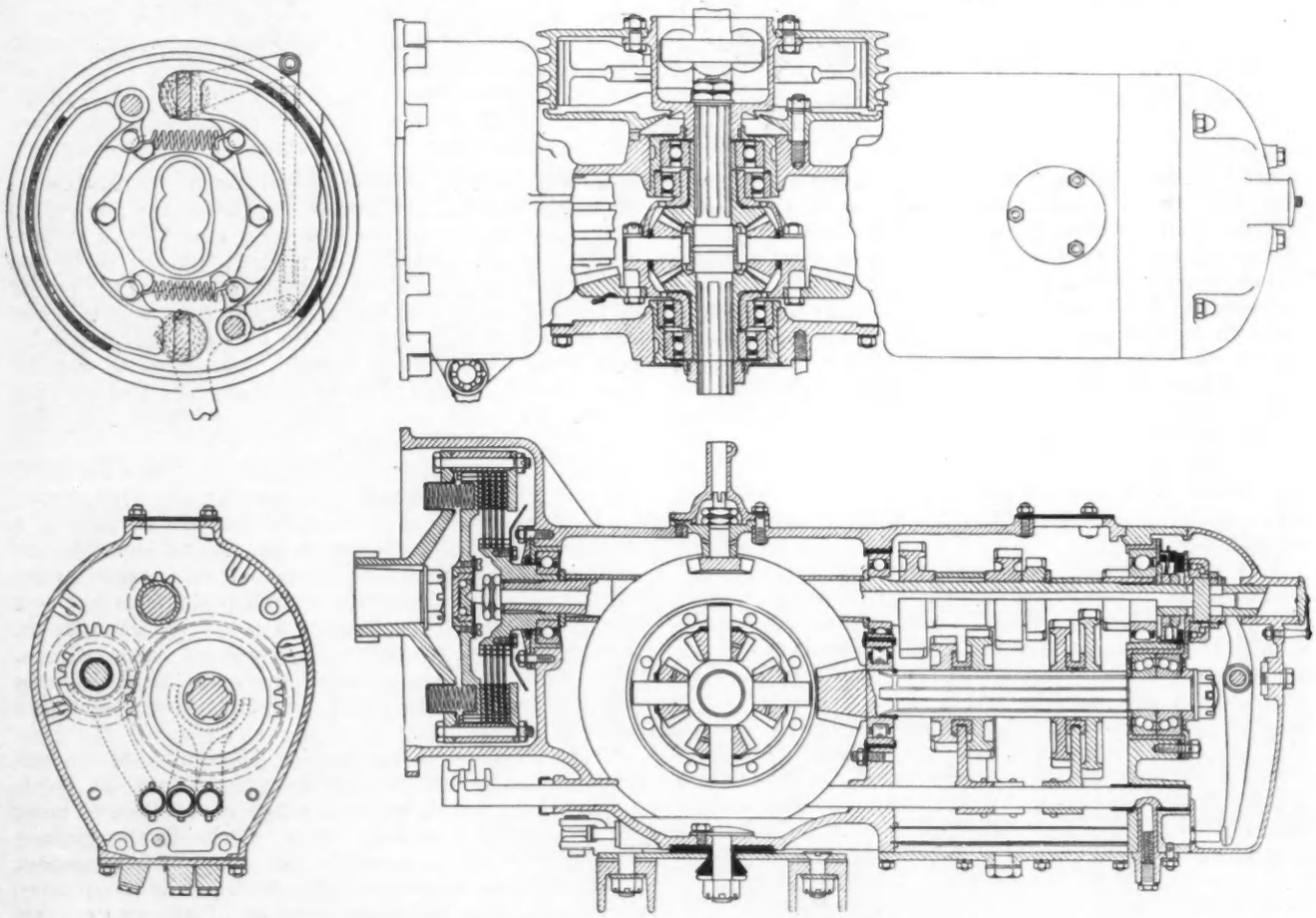


FIG. 7—SECTIONS AND VIEWS OF ALVIS TRANSMISSION

The Entire Transmission of This British Car Is in Front of the Front Axle. No Direct Drive Is Provided. The Speedometer Drive Is Taken by a Bevel Pinion Meshing with the Bevel-Drive Gear

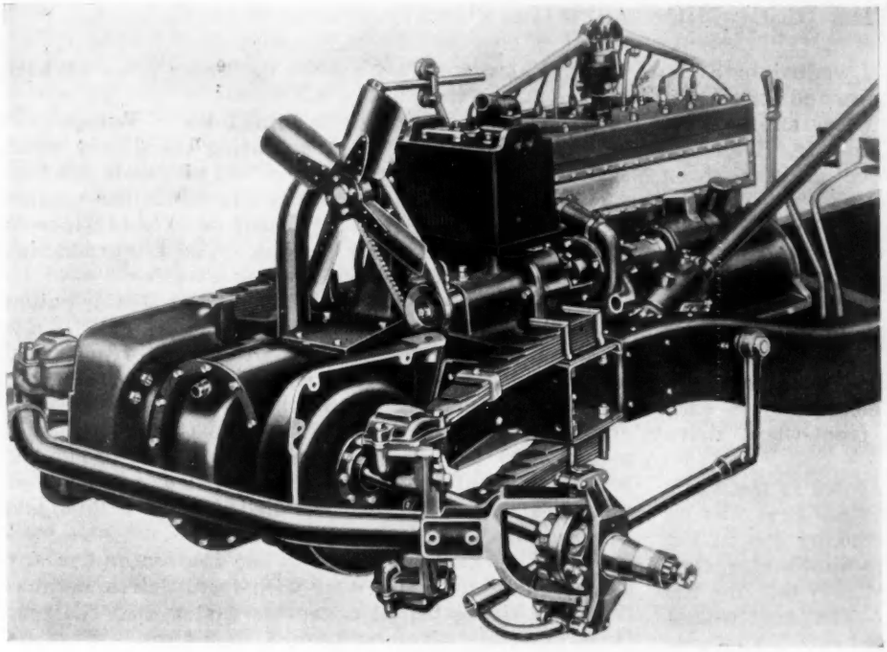


FIG. 8—CORD POWERPLANT AND FRONT AXLE

with a number of new problems not met in the designing of conventional cars, probably chief among which is the designing of a front axle having both steering-knuckles and driving members. The transmission line between each differential side-gear and the road wheel on the same side is in three parts: a short shaft fastened into the side-gear, a short shaft fastened to the driving wheel and passing through the hollow spindle of the steering-knuckle, and a longer shaft connecting these two with universal-joints. These universal-joints must compensate for two kinds of relative motion between the differential and the driving wheels: the motion due to spring play, and deflection of the driving wheels for steering. The angular relation between the connected shafts changes whenever the springs compress or rebound, and the angular relation between the long shaft and the short shaft in the knuckle spindle changes whenever the knuckle is deflected for steering.

A characteristic of the ordinary twin-yoke universal-joint is that—if it connects two shafts making an angle with each other, and the driving shaft turns at absolutely uniform speed—the driven shaft will alternately speed up and slow down, passing through two maximum and two minimum speeds during each revolution. Such fluctuation is very undesirable for an automobile drive-wheel, as slipping and wear of the tires would be inevitable. Fortunately, the fluctuations in the speed of the driven part can be eliminated if two universal-joints are used, with the yokes on the intermediate shaft in the same plane and the end shafts so mounted that both joints must constantly operate at equal angles. By placing one joint at the knuckle and another at the differential, changes in relative position of wheel and differential due to spring motion can be compensated for without introducing irregularities in the drive.

However, when the front wheel is deflected from the straight-ahead course, the angle of the joint at the steering-knuckle changes, while that of the joint at the differential does not. Therefore it is at least desirable to use at the knuckle either a universal-joint of a type that transmits motion uniformly at all angles or two yoke-type universals placed close together and so arranged that the angles of both are always equal. The center point of the universal-joint assembly at the steering-knuckle should lie in the axis of the knuckle pin, for obvious reasons.

The ends of the axle-center member must be of such design that they do not interfere with the driveshafts. If they are of yoke form, the yokes may be swung around as seen in Fig. 8, instead of being in the transverse vertical plane through the wheel axes. A number of other designs can be worked out, but the problem will tax the ingenuity of the engineer.

Engine Position and Appearance

Since the engine is turned end for end from its conventional position, provision of a simple drive for the radiator fan and of means for applying the starting crank are problems that demand consideration. The entire cooling system, in fact, has to be arranged somewhat differently than in a rear-drive car. If the radiator is to be placed in the usual position with relation to the length of the car, it will be on top of the drive-gear housing and therefore cannot extend down as far as it usually does in modern rear-drive cars. This presents a somewhat knotty problem, especially in view of the fact that raising the radiator and engine hood and simultaneously lowering the seats makes it more difficult for the driver to see the road immediately in front of the car. There are, of course, numerous possible ways of providing sufficient radiator capacity without shutting off the driver's view.

With front drive the appropriate "dressing up" of the front of the car is somewhat more difficult, since there is of necessity a gear-housing of considerable bulk at the center, but American designers have succeded in solving this problem very satisfactorily.

The front driving-wheels are independently sprung in several European designs. Independent suspension of the front wheels, however, is a separate feature that can be combined also with rear drive.

Relative Advantages Weighed

Summing up, front-wheel drive makes a lower body floor possible by eliminating the propeller-shaft. This leads to a lower center of gravity, greater stability and increased safety at high speed; it reduces the unsprung weight, thereby improving the riding-qualities and adding to tire life; and it reduces the slewing tendency on turns, permitting higher speeds with safety on winding roads.

On the other hand, with the same engine and the same body space, the front drive calls for a longer wheelbase, and up-grades and torque reaction have the effect of reducing the maximum tractive force obtainable, whereas with rear drive they increase it.

THE DISCUSSION AT MILWAUKEE

MEADE F. MOORE[5]:—Last month I visited both the Paris and the London automobile shows and found that the European designers are making every effort to get their cars lower. Many designers, as Mr. Heldt has mentioned, are mounting the differential housing on the chassis frame and springing the rear wheels independently. This makes it possible to place the rear-seat cushion directly on top of the differential housing and eliminates the relative motion of the propeller-shaft.

Other designers have made a hump in the rear floor for the propeller-shaft. Most cars of this type are four-passenger sport jobs, in which the two rear passengers must place their feet in two little boxes, one on each side of the propeller-shaft. The front-wheel drive probably offers a better solution.

Four front-wheel-drive cars were shown in the Paris Salon, if I remember correctly. One of them was an American design and was the best-looking job in the show. One of the outstanding four-wheel-drive cars was the Bucciali. Although I am not very tall, the top of that car came only up to my chin. The front wheels are individually sprung, with the wheel spindles mounted on something like a bell-crank and a cross spring in front of the radiator. To make the cross tube that supported the frame from the spring look passable, the designer mounted the head-lamps on it. Two of the other models were sport cars, as most of the front-wheel drives in Europe are, and were offered with superchargers.

At the London show, there was not a front-wheel drive; but I saw the experimental Alvis car that had two four-cylinder engines geared to a central drive-shaft. That would have to be much improved before the American public would accept it. I was told that the gears used at the time were herringbone instead of spur gears.

Front-wheel drives now seem to be very complicated, but it is not fair to criticize too severely these first attempts of the designers. The first four-wheel brakes were not equal to those of today, and the front-wheel drive will be improved during the next five years. The trend of design, not the mechanical advantages, will determine the future of front-wheel drives.

Big Production Makes Conservatives

H. PALMER[6]:—Why is it that American designers seem to have paid so little attention to separately sprung wheels, which seem to be very prominent in Europe? Is there any particular disadvantage in the design or any reason to fear it?

P. M. HELDT:—At a former S.A.E. meeting, some of the designing engineers said they thought that such a radical change as from rigid axles to independent springing, in a part on which safety depends so much, would meet with much sales resistance. Besides, none of the independently-sprung-wheel constructions looks very neat, even if the parts are covered by an apron. But there is an advantage in independent springing, because of the reduced unsprung weight.

MR. PALMER:—The French designers seem to have more courage than we have.

MR. HELDT:—Most of the companies in Europe that launch these novelties are operating on a very small scale. If they produce a car that the people do not like, they design a different one, but our companies operate on such a big scale that they must be very cautious or the results may be very serious. The big-production companies abroad are equally conservative.

MR. PALMER:—Is there such a thing as a basic patent on the application of the drive to front wheels?

MR. HELDT:—No basic patent on the front-wheel drive exists, but any design must be worked out in a definite way, and the details might infringe some patent. I have received a letter from a German, whom I met in 1900, who claims that he can produce proof that he built a front-drive car in 1905. It was not much of a success, but he had one embodied in steel in 1905, and the ordinary life of a patent is 17 years.

J. C. SLONNEGER[7]:—I fail to see the reason for any claim of decreased tire wear with front drives, because the front tires of most cars wear faster than the rear tires, especially since we have balloon tires. It is said that the wheels are out of alignment if the front tires wear faster, but the front tires wear faster on all the cars with which I have had experience, in spite of the fact that rear-wheel spinning is supposed to wear off much rubber. Front-driving would augment that condition rather than relieve it.

The speed at which we dare to take a curve depends on how well we can see ahead and how quickly we can stop. Very few accidents on curves are caused by cars skidding; most of them result from taking the curves so fast that the driver cannot stop when unexpectedly confronted with something. I do not see that the front-wheel drive is of any advantage in this respect.

Danger from Slipping Front or Rear Wheels

MR. HELDT:—The last time I mentioned in an S.A.E. meeting the subject of locking the front wheels in braking, H. H. Allen, who has done a great deal of work on brakes at the Bureau of Standards, questioned the view that it is more dangerous to lock the front wheels than the rear wheels; and, after thinking it over, I have come to his opinion that the opposite is true. If the rear wheels are locked, an immediate skid is almost certain. Sometimes it can be corrected, and a front skid can always be corrected. With the front wheels locked, the car is likely to go straight ahead but control can be secured again immediately by relieving the brake pressure. To say the least, I am not sure that locking the front brakes is more dangerous than locking the rear brakes.

MR. SLONNEGER:—The difference is that, if the front wheels are locked, the inertia force is behind the dragging front wheels, resulting in instability; whereas, if the rear wheels are locked, the dragging is behind the inertia force and has a steering effect on the dragging wheels.

MR. HELDT:—If the front wheels are locked the rolling contact between the rear wheels and the ground assures stability; experiments with front-wheel brakes have shown that quite conclusively. If the front wheels are locked while in the straight-ahead position, the car will continue to pursue its course; if they are locked

[5] M.S.A.E.—Chief engineer, Nash Motors Co., Milwaukee.

[6] Kissel Motor Car Co., Hartford, Wis.

[7] M.S.A.E.—Technical advisor, International Harvester Co., Milwaukee.

while deflected from the straight-ahead position, there will be a front-wheel skid, the whole car moving along a tangent to the circular path for which the steering wheels are set, but the rear wheels will keep on rolling and the rear end of the car will not slew.

MR. SLONNEGER:—I have heard of a man who applied the brake too hard on a roller-coaster while going down a steep incline, with the result that the car tipped over forward. Had the front wheels kept on turning, the rear wheels would have dragged and the car could not have turned over.

H. L. ZIMMERMAN[8]:—I have knowledge of an experimental car built with only front-wheel brakes and driven through a winter on icy pavements, and it was impossible to skid that car. The driver could lock the front wheels but could never swing the car end for end, because the rear wheels kept their traction and always moved in their own plane.

When the Buick first appeared with four-wheel brakes, provision was made for adjusting the brake pull from equal at the front and the rear to about 35 to 40 per cent at the front and 60 to 65 per cent at the rear, and the decision as to which was preferable was left to the driving public. But the tendency in recent four-wheel-brake design is to put 60 per cent of the braking effort on the front wheels and 40 per cent on the rear, because deceleration throws more of the weight of the car on the front wheels and more braking effort can be applied to them than to the rear wheels without sliding them.

CHAIRMAN A. C. WOLLENSAK[9]:—Have you given any consideration to the front-wheel drive, Mr. Heldt, in connection with commercial vehicles? Its possibility for trucks seems remote, because 85 to 90 per cent of the live load is on the rear wheels.

MR. HELDT:—I think you are right. Front-wheel drive is being used to a very slight extent by Latil, in France, for special purposes, like transporting race-horses. It can be used in a level country when a very low platform is needed, but I cannot see any advantage in the front-wheel drive for a general-purpose truck that is to be sold throughout the Country.

Controlling a Skidding Car

A VISITOR:—With a conventional rear-drive car, it is best to take the foot off the accelerator when a skid starts. Does it not follow that the best thing to do with the front-wheel drive, under the same circumstances, is to "gun" the engine?

MR. HELDT:—I have not driven a front-drive car but have heard that it is necessary to put on power to get out of a skid.

A VISITOR:—Would that cause any serious damage, because of the angularity of the universal-joint being at its maximum, from trying to counteract the skid by steering?

MR. HELDT:—I cannot see that any extra stress would be imposed on the universal-joints if they are double.

A VISITOR:—I thought cars went to pieces at the Indianapolis races because the drivers gunned the engines on the turns and thus injured the joints, which might have been satisfactory for ordinary use, pulling straight ahead most of the time and not using full power at turns.

A SECOND VISITOR:—I have driven a Cord car a short distance, and it seems very safe. I did not notice any skidding in going around corners.

A THIRD VISITOR:—The universal-joints travel at front-wheel speed, not at engine speed, and they deliver constant velocity; and, regardless of the steering angle, there is no "bucking" of the front wheels, as in a rear-drive car, so there is no wheel-fight.

MR. HELDT:—The lack of steering-wheel fight may result from the method of springing the Cord car, which probably gives the same effect as the arrangement on such cars as the Packard and Hupmobile that allows the front axle to yield to shocks.

THIRD VISITOR:—What I meant by wheel-fight was the rear wheels bucking against the front ones.

MR. ZIMMERMAN:—Mr. Heldt made the statement that 40-deg. angularity is possible in a universal-joint for steering. I know of no conventional rear-drive car that needs an angularity greater than 35 deg. at the inside front wheel to get a turning radius which is commonly acceptable.

MR. HELDT:—Perhaps 35 deg. is enough, the amount needed depends upon the judgment of the designer.

L. J. D. HEALY[10]:—Must the front wheels of front-drive cars be parallel in the straight-ahead position, or do they have a slight toe-in, as in rear-drive cars?

MR. HELDT:—These questions of camber and toe-in are not definitely settled; the S.A.E. has a committee investigating it. A small amount of toe-in is desirable, as in any car.

Relative Tire Wear

MR. HEALY:—Can Mr. Debbink give us any information as to the relative wear of front and rear tires on motorcoaches?

H. L. DEBBINK[11]:—That varies a great deal; on motorcoaches on which we have changed from high-pressure to low-pressure tires, we have found considerably more wear on the front than on the rear wheels. When we get the axle bent to the correct camber and toe-in for balloon tires, the condition is reversed in most cases and we find more wear at the rear; but the percentage of weight on the rear wheels of a motorcoach is much greater than on the front wheels.

Some mention has been made of failures of front-wheel drives on race tracks. These may have been due to some unusual stresses. Were not most of the failures of front-wheel-drive cars on the Indianapolis track during the last few years due to the accessory drives, especially supercharger drives? I have heard the opinion expressed by observers that these supercharger drives failed because of the transfer of weight resulting from the torque reaction under conditions of maximum traction, which allowed more slippage of the driving wheels. This slippage would throw an enormous strain on the supercharger drives and probably was the cause of their failure.

MR. HELDT:—That sounds reasonable; the supercharger drive is a very delicate mechanism and the inertia is very great at such high speed. I believe that supercharger drives often fail on rear-drive cars also.

MR. PALMER:—What problems are involved in adapting a conventional eight-cylinder engine to a front-wheel-drive chassis?

[8] M.S.A.E.—Assistant engineer, Nash Motors Co., Milwaukee.

[9] M.S.A.E.—Chief engineer, Sterling Motor Truck Co., Milwaukee.

[10] M.S.A.E.—Technical superintendent, Fisk Rubber Co., Federal Division, Cudahy, Wis.

[11] M.S.A.E.—Superintendent of gasoline vehicles, Milwaukee Electric Railway & Light Co., Milwaukee.

MR. HELDT:—Many detail problems have to be solved in such an installation. One is that, when a stock engine is turned end for end, provision for driving the fan is difficult to make; another is the arrangement of a hand starting-crank, and still another is the location of the radiator. I suppose that, for the present at least, the front-drive passenger-car will be expensive and powerful, and it is a problem of some importance to get the cooling that is required when the transmission occupies the lower part of the radiator space.

THE DISCUSSION AT NEW ENGLAND

DAY BAKER[12]:—What is the tractive resistance of the front-wheel drive, compared with that of the rear-wheel drive, in climbing hills and grades?

MR. HELDT:—I believe that there is absolutely no difference on good roads, but the front drive tends to climb out of a mud-hole slightly better than the rear drive. The force is tangential to the circumference of the wheel, and, if the push is from the rear, the tendency is for the front to work in deeper and deeper. The front drive has less resistance on soft ground, but on hard roads such as we have in the East, the resistance would be exactly the same for the two cases.

MR. BAKER:—Nearly 20 years ago we built some trucks for climbing the gang-planks of ships; and we made them with front-wheel drive, because they could climb so much better than with rear-wheel drive. The load was divided equally.

MR. HELDT:—I should expect front-wheel drives to have an advantage under road conditions similar to those you have described.

MR. BAKER:—Some years ago, with a rear-drive car, I got into a snow-bank that was so stiff that I could not drive through it, so I turned around and backed through. The chains on the rear wheels ate their way into the snow and made a track for the front wheels. I do not think that front-wheel drive is of any particular advantage except in traveling through snow, mud or sandy soil where the front wheels can climb against the resistance and make a track for the rear wheels.

Comparative Tests Made Years Ago

H. B. CHURCH[13]:—I made some tests with four-wheel-drive electric trucks many years ago. I disconnected the front motor and took ammeter readings while driving the car in a circle, with the front wheels deflected to turn at an extreme angle; then I reconnected the front motors and disconnected the rear motors and repeated the experiment. Much less current was consumed when the front drive was used. That is because the power was being applied in the direction in which the car was to move.

No difference was found on a smooth road, either on a level or on a hill. I think those tests throw light on the question of the tendency to skid on turns, which is less in the front-drive car because the power is applied in the direction in which the car is to move. I also believe that the front-drive car will climb out of deep, icy ruts more readily than the rear-drive car, but the loss in tractive advantage due to the torque reaction and the shifting of the center of gravity on an incline seems to be a serious point against the front-drive car.

GEORGE APPLEYARD[14]:—Have you any figures regarding the life of front-drive universal-joints? I was at the Rockingham race track before the races, and it seemed to me that the mechanics were spending considerable time on the universal-joints of the front-drive racing cars. Would universal-joints on these cars require more attention than on rear-drive cars in regular passenger-car service during a 10,000-mile period?

MR. HELDT:—I think that is largely a matter of the size of the universal-joint. Any mechanical device that is made too small is overstressed and will give trouble. If universal-joints are made large enough they will not give trouble. That much power is lost in a universal-joint is a misapprehension; but a construction in which a single conventional universal-joint connects shafts making a large angle with each other and carrying a large load would involve heavy masses. A tremendous strain would be set up somewhere along the line, because of the fluctuation in speed that cannot be produced without the application of large forces. So, great strains are possible with that sort of construction. In ordinary work with universal-joints, no great loss of power or wear results, because the movement is slight.

Tire Chains, Skidding and Noise

C. C. LAWTON[15]:—Skid chains would have to be applied to the front wheels with front-wheel drives. What effect would they have on the steering, as to shimmy?

MR. HELDT:—I do not see that front driving can have much effect on those questions.

There has been much discussion as to skidding and the relative difficulty of driving with front-drive and rear-drive cars. In my opinion, the front-wheel skid is not nearly as serious as the rear-wheel skid. A front-wheel skid can occur with front-wheel drive if the engine is throttled while making a turn. That is the usual thing to do and it works all right with rear-drive cars, but it must not be done with front-drive cars because it makes the engine act as a very powerful brake. The momentum tends to carry the car along at a certain speed, and the front wheels cannot revolve so fast because the engine is holding them back. The result is a front-wheel skid; the front wheels, instead of moving in the direction in which they are deflected, will slide at an angle thereto. The front-wheel skid can be corrected by opening the throttle or releasing the clutch, and the clutch should not be engaged again quickly. A rear-wheel skid, once started, is hard to correct.

A VISITOR:—One of the things that I expected of the front-wheel-drive car was freedom from noise in the back seat of the sedan. The noise did not seem to be entirely due to the muffler; there was as much or more rumble and vibration as with the rear-wheel drive. I was surprised to find that. To what was it due?

MR. HELDT:—It might be due to a peculiarity of the body construction. I have noticed that the rumble in any car occurs when the engine is pulling hard, and engine conditions are the same with either drive.

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[12] Secretary and treasurer, Motor Truck Club of Massachusetts, Boston.

[13] M.S.A.E.—Treasurer, manager, H. B. Church Truck Service Co., Boston.

[14] M.S.A.E.—Service manager, partner, Robinson-Toohey Co., Lawrence, Mass.

[15] A.S.A.E.—Service manager, Worcester Buick Co., Worcester, Mass.

Body Design and Construction in Europe

By THOMAS L. HIBBARD[1]

ANNUAL MEETING PAPER *Illustrated with* DRAWINGS

COACH builders in Europe have an important advantage over builders in America in the extent and importance of the custom-body business. As most of the European manufacturers of de luxe chassis do not build bodies, there is a constant demand for bodies built to suit the varied tastes of a clientele accustomed to ordering special bodies. The purchasers are able to have their ideas incorporated in all their cars, and so a great part of our medium priced and de luxe cars reflect the choice and judgment of the users rather than of the manufacturers of the chassis.

It is also customary for coach builders in Europe to act as retail agents for cars of various makes. Because of these conditions, body builders are able to develop their own ideas as to appearance and design from the body-builder's viewpoint, which frequently is at variance with that of the chassis engineer and manufacturer. Therefore we have a large amount of latitude to work out new ideas in design, and more novelties are developed than here, where the custom-body business is not specially important and where the car manufacturer is greatly handicapped in the free development of new models.

The importance of body design has now reached a stage at which it has a great bearing on the success of any manufacturer's line of cars. The public has been self-educated by constant contact with motor-cars to the extent that it is almost impossible to tell the buyer that a certain body design is beautiful or the body layout practical. If the prospect has been a user of good cars for the last 20 years, he often is better able to judge the merits of a body than is the salesman who sells the car, the engineer who designed it, or the manufacturer who built the car or the body.

Those of us who sell at retail, as well as design and build coachwork, are aware of the generally accurate judgment displayed by car buyers in selecting bodies. This holds true all over the world; we encounter the same problems in putting over a design in Europe as are encountered in America. Color schemes that are not in good taste, upholstery that is ugly and lines that are poor drive buyers away from builders abroad as they do here.

Coach Work at European Exhibits

The large international exhibitions, like the Olympia Show in London and the Paris Salon, afford an opportunity to coach builders to introduce new body styles and give car manufacturers a chance to test out the popularity of these new designs. Most car manufacturers show several special body jobs on their stands as well as their standard coachwork, if they have a standard line. Therefore many special bodies are on view at these shows, and the exhibitions are more attractive to the public because of the large number of novelties offered.

The same tendency was revealed at the recent automobile show in New York City. A number of custom-built bodies were displayed on American chassis of various makes, and they attracted much attention. I think it would pay manufacturers here to spend more money on custom bodies to exhibit among the stock cars at the National shows. People go to the automobile shows to see something new. It is a great mistake for exhibitors to show only the standard lines, many of which have been seen previously in salesrooms throughout the Country; the public

[1] Hibbard & Darrin, Paris, France.

THOMAS L. HIBBARD

Building custom bodies is on a different basis in Europe than in America, because many of the leading motor-car manufacturers build no bodies. A large proportion of the more expensive chassis are sold without bodies, and many of the coach builders make retail sales of chassis.

European automobile shows and salons feature the body-builders' art in great variety. Small production and hand work favor variety in design.

Custom bodies often are excessively heavy. A debt is acknowledged to Weymann for his demonstration of the possibilities of light-weight bodies. Several metal and other novel structures are briefly described, including one body having a cork exterior.

Needs of the body industry include more real designers and more facilities for research on materials and metals.

Sketches showing structural details of the author's metal bodies are given in the discussion, which also considers the subjects of cork covering and squeaks and rattles.

is not interested in seeing the same design again.

Most of the European resorts, during the height of their seasons, hold elegance competitions at which body designers have a chance to submit their latest creations to the buying public. Some of the most successful of these competitions have an amateur status; that is, the exhibitor of a car must be the owner and not connected with the motor trade. Often we are told, in designing a special body, that it is to be entered in a certain competition and are urged to originate something very special which will have a chance of carrying off a prize. At the competitions on the French Riviera, during the winter season, one sees perhaps the finest assemblage of motor-cars that it is possible to see anywhere in the world. Competitors come from all over Europe, and English support is such that one sees almost as many Rolls-Royces as cars of any other one make. These contests are a real stimulus to designers, and some of you would be amply repaid for attending them.

Dearth of Artists in Body Design

The fact is constantly being forced home to me that, in Europe as well as in this Country, coach builders are greatly handicapped by lack of talent in body designers. Not enough serious effort is being devoted to the education of real designers of motor-car bodies. By designers I mean men who are able to create new lines, details and interiors; not mere body draftsmen. The work of the body designer is often of more importance in selling a car than is that of the engineer who laid out the chassis. However, the body designer probably has had to educate himself, earns a small salary compared with that of the chassis engineer, has poor facilities with which to work and is generally regarded as on a lower plane professionally than the importance of his work merits.

Aside from the apprentice school in Paris, run by Riegel, almost no way is provided for a boy to learn body designing in France. London has a school which I understand attaches more importance to the drafting course than to the actual design of bodies. I believe that we rely too much on drafting and designing being taken up by the sons of men who are in the construction end of the business. This is especially true in Europe and is reflected in the gradual decline in the origination of good designs. Boys with artistic inclinations are much more likely to develop into good designers than are those who merely take a course in designing with the intention of later going into the purely mechanical side of the business. Some efforts should be made to attract suitable talent to this business.

The greatest period of development in the designing of automobile coach-work was between 1910 and 1914.

Small Production Favors Novelties

Many novelties in body construction are evolved in Europe because of the large amount of handwork on the bodies built there, which affords builders great opportunity to try new methods and materials. The advantages of the all-metal body are recognized by various European builders and several of us are working on the problem; but we are under a considerable handicap, because we have neither the equipment nor the large output necessary for pressed-metal construction. However, the difficulty and expense involved in securing good wood are forcing us toward some substitute and most of us incline toward an all-metal type of construction.

In France, Voisin has been building all-metal bodies for some time. His creations always embody many novelties and are well worth study. His cars as a whole do not follow the general style in appearance or layout and, while all features of his bodies may not be acceptable, his solutions for many problems are very ingenious and meritorious. He is one of the greatest exponents of light-weight bodies and rightly recognizes the great bearing of weight on acceleration. Many of the ordinary coach-built bodies in Europe are excessively heavy. The influence of Weymann has been most beneficial in this respect, as he certainly was one of the pioneers of the light-weight body and educated the public to appreciate its advantages.

As I have been in this Country for more than two months, I am unable to say what success Weymann has had since the Paris Salon with his new composite construction, using the articulated wood frame covered with metal. He was forced to this because motorists tired of the appearance of the fabric-covered body and by the difficulties encountered in attempting to use a fabric coated with cellulose, which was intended to give a smooth surface like that of a metal-panelled body.

Maurice Snutzel, of Brussels, exhibited a very interesting body at the Paris Salon. This consisted of a wood frame having an outer covering of cork, similar to linoleum, in various thicknesses. Apparently the material was easily worked, as it was carried around the corners nicely. All the uneven spots in the cork were patched up by putting thin strips of cork into the depressions. The entire body was primed and coated with cellulose, and it looked like a metal body. It had the advantages of being light and unaffected by climatic conditions. The material is a good insulator against the passage of both heat and sound.

All-Metal Bodies Being Developed

An interesting construction has been originated in France by the Marbeuf company. This is very simply worked out, consisting merely of shaped metal panels the edges of which are turned in to form flanges. These flanges are bolted together with a rubber strip between to make a tight and noiseless joint. The doors of these bodies are very light and have about the same degree of flexibility as the Weymann fabric-covered doors. A very ingenious lock was used in these bodies at the Paris Salon. It had a conical bolt which was drawn back in the regular way. When the handle was turned to open the door, the bolt was held back by a catch and was released by a separate trip device only when the door was closed. The action was similar to cocking and firing a gun; the door could be closed with almost no effort, and the bolt was driven home by the stiff spring.

My own firm has been working for some time on all-metal bodies and has two types of construction well developed and adaptable to fairly small production. In one type of body we make the doors with a cast aluminum-alloy frame covered with a sheet-aluminum panel, and build up the cowl and rear panels in the same way. In the other type we cast the entire exterior of the door in one piece and build up the other panels from castings. This last method is in some respects preferable but requires exceptional foundry facilities, alloys considerably lighter than the ordinary casting-alloys and very difficult pattern work.

Our models are designed around a panel construction stopping at the belt, as a great proportion of our bodies are collapsible. The roofs of bodies having solid roofs are separate structures. We find our metal bodies lighter, stronger, more easily reparable and much less sensitive to climatic variations than bodies built over wooden frames.

It is to be regretted that Lancia, because of his limited output, has not been able to work more on the body problem. The first Lancia models were a most interesting development which merits the serious attention of American manufacturers who have the means to carry out the idea. In these Lancias, the pressed-steel body was built so that no chassis frame was necessary. This construction would be easy to incorporate in a front-wheel-drive car.

Airplane Construction Advocated

A type of body construction that as yet has not made great headway but which merits attention because of its weight-saving possibilities is one in which the framing is composed mostly of drawn tubing, such as is now being widely used in aircraft construction. The difficulties of adapting tubing to body construction are not great and use could be made of much pioneer work done by the aircraft industry.

With the facilities of factories and laboratories in the United States, more attention could and should be given to developing new methods of construction than is given to this problem in Europe. A much wider variety of body-construction processes is employed abroad than here, where there seems to have been little research on new methods and processes. We break away more from the conventional methods in Europe, and I believe that American engineers should be given a greater opportunity to try to perfect body construction through striking out more from the beaten track and attacking the problem in a broader way.

Manufacturers do not give body engineers enough facilities for working out new ideas. Much could be accomplished in body work by more research and experimentation along new lines, especially with new materials. We have rather fallen into a rut in body construction and design.

In the early days of the industry, the pioneers made rapid strides by trying daring innovations. I believe that, while giving the proper attention to detail, body engineering could be greatly advanced through bigger appropriations from manufacturers for research and development work. The results obtained would contribute greatly to the general progress of the industry and justify the added expenditure.

THE DISCUSSION

CHAIRMAN HENRY R. CRECELIUS[2]:—The all-metal body has great advantages for use in all kinds of weather and climatic conditions. Can you, Mr. Hibbard, show details of your all-metal construction?

T. L. HIBBARD:—Designing an all-metal body was difficult for us because we build only a few bodies during a year and we may be building a Rolls-Royce body one day and a body for a small, cheap car the next day. Most of our work must be done by hand.

Before we started in a serious way on the problem of the whole metal body, we built a few bodies with the doors, which we consider the weakest part of the body, made of metal. We thought that solving the problem of the doors would take us far toward the solution of many of the difficulties that we encountered, particularly because of climatic conditions in countries to which we exported composite bodies. These bodies were made with door frames consisting of aluminum castings, the upper casting serving as the outside surface, as shown in Fig. 1. The same design was used in cars having standing tops, by adding a rigid frame above the belt.

The castings were joined by bolts at *A* and *B*. Steel strips were placed at each side and at the bottom, and a sheet-aluminum band was placed over the steel strips and bolted to the panel underneath the molding edge, so that the joint is covered by the molding, as shown in the detail at the left in Fig. 1. We produced about 25

[2] M.S.A.E.—Body engineer, Lincoln division, Ford Motor Co., Detroit.

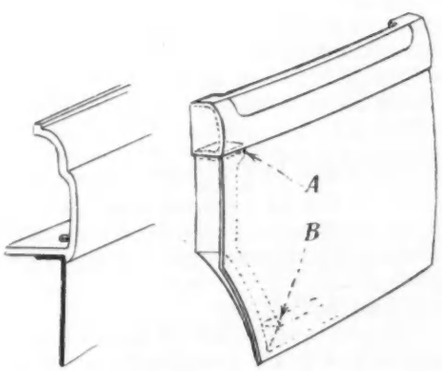


FIG. 1—SHEET-METAL DOOR ON CAST-ALUMINUM FRAME

The Detail at the Left Shows How the Upper Casting, Which Is Exposed, Is Joined to the Lower Part of the Door

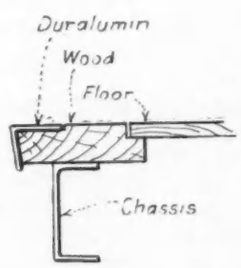


FIG. 2—SECTION OF WOOD FILLER AND DURALUMIN BODY-SILL

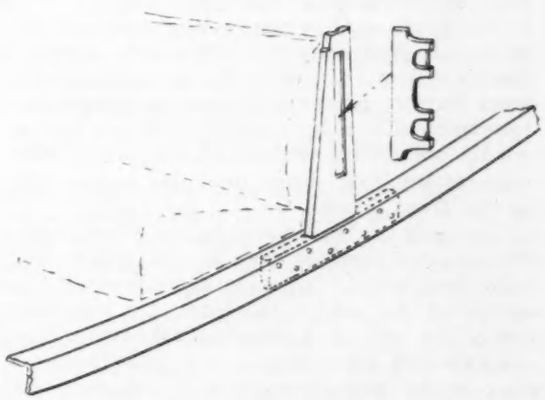


FIG. 3—SKETCH SHOWING FORM AND ATTACHMENT OF HINGE PILLAR

bodies with doors of this sort. Although we had some difficulty with the castings because of our inexperience, these doors have been perfectly satisfactory. Accordingly, we decided to build the entire body of aluminum.

Duralumin Sill and Hinge Pillar

This brought up the serious problems of how to make the sill and the hinge pillars. Because of the rivets and irregularities of the chassis frame, we decided to use a wood filler, as shown in Fig. 2, which corresponds to the sill of an ordinary body. This is the only wood we use in the frame, and it is not a strength member.

Along the outside of the wood filler comes the true sill, which is made of duralumin. This is of heavy section and is placed at the outside, so that it is visible when the door is open and serves as a scuff plate. The floor boards rest on the wood filler. The duralumin sill follows the contour of the body. As we have no heat-treating facilities, we have this member formed outside.

Hinge pillars are formed from a duralumin plate 18 mm. (approximately 11/16 in.) in thickness. This member is roughly in the shape of an inverted T, the bottom part being riveted to the duralumin sill and the upright penetrating the sill, as shown in Fig. 3. The front side of the upright is sloped, following the line of the back of the driver's seat, and the upright is mortised for the separate member shown, which forms the support for the hinges. Both front and rear doors are carried on the two hinge-pins shown in Fig. 3. The hinge pillar is attached to the sill by aluminum rivets, by means of a hydraulic riveter of French manufacture, which forms the heads perfectly and unites the two parts so they cannot be separated without drilling out the rivets.

HENRY R. CRECELIUS

At the rear of the sill is another duralumin angle which is riveted to the sill and forms the first quarter of the wheelhouse. The remainder of the structural parts are of aluminum castings, made of alloys varying according to the stress. Aluminum is ordinarily used where there is not much stress, and Alpax for the more highly stressed members.

Doors are made either with aluminum frames covered with sheet aluminum or entirely of cast aluminum. We have had some difficulty in casting doors in one piece because of the large area and small section, but we expect to be able to secure such castings later, keeping the weight below that of a composite door. We are now casting rear doors for some bodies and building up the front doors.

The back of the body consists of a frame made up of aluminum castings such as I have described, covered with sheet metal. The castings are carried around the outside of the body in the form of a belt molding. The rest of the body is of conventional construction.

CHAIRMAN CRECELIUS:—Are your bodies bolted in place in the conventional way or self-supporting?

MR. HIBBARD:—The duralumin sill is bolted to the wood filler, and the wood filler is bolted to the chassis frame in the usual way.

[3] M.S.A.E.—Assistant editor, *American Machinist* and *Product Engineering*, New York City.

Roofs—Collapsible and Cork

A MEMBER:—I should like to have Mr. Hibbard explain the roof construction of his closed bodies.

MR. HIBBARD:—About 75 per cent of our bodies are collapsible. We use ordinary construction except that the bows are metal instead of wood. Some of them are made of steel tubing, but the rear bow is made up of Alpax castings, which are somewhat malleable and strong enough for the purpose. Our standing roofs are built over a metal framework, sometimes with a skeleton top of duralumin strips. The framework is covered with woven wire and padding in the conventional way.

We are experimenting with roofs made from metal castings, bolted together, but have not spent much time on the problem of standing roofs because such a large proportion of our bodies are collapsible. Except for the new cast roofs under development, we use soft sides as well as soft tops. The new roofs will have soft centers. I have considered using cork, such as I have mentioned, for the center of the roof, with a cellulose finish to match the metal panels.

CHAIRMAN CRECELIUS:—Have you had experiene in the use of cork?

MR. HIBBARD:—We have not, ourselves, but I am convinced from what I have seen that the cork can be handled easily. The coating is waterproof and the cork itself is not affected by water.

CHAIRMAN CRECELIUS:—Our experience is that cork will absorb water, no matter how it is coated, and that the absorbed moisture causes a change in shape.

MR. HIBBARD:—I took up that point with those who produced the body. The backers of the idea, who are manufacturers of linoleum floor-covering, assured me that they have had plenty of experience with the material. One of the advantages of linoleum floor-covering is that it will not swell when it is washed; it may be wavy but it does not become thicker when it is wet.

CHAIRMAN CRECELIUS:—We have heard of a case in England where cork did not prove good for body work because it became distorted in the moist climate.

MR. HIBBARD:—The makers of this material have a patented process for preparing it. The cork is ground and held together by a binder, the properties of which I do not know. The makers aver that it is not affected by climate or moisture.

Fewer Joints Make Fewer Squeaks

QUESTION:—Are you troubled with squeaks and rattles in a body such as you describe? Do your cars operate entirely on paved roads or on rough dirt roads to a considerable extent?

MR. HIBBARD:—We have plenty of rough roads, and the problem of squeaks and rattles led us to study the metal body. We find that there is less chance for noise in a metal body because it has fewer parts and joints. Reinforcing the corners of window frames with various materials is not necessary.

HERBERT CHASE[3]:—I should be interested in a descrip-

(*Concluded on p.* 378)

Garage and Shop Design

By ALBERT KAHN[1]

TRANSPORTATION MEETING PAPER — *Illustrated with* DRAWINGS

PRIME consideration must be given to the garaging and servicing of fleets of vehicles, according to the author, because numerous corporations operating on a large scale have come into existence in the last several years. After mentioning the variations in dimensions of motorcoaches and motor-trucks, he discusses the multiple-story structure and specifies the requirements of design, afterward going into detail concerning the planning of a motorcoach garage, particularizing on numerous details that will tend toward ease of operation and economy in both housing and servicing the vehicles.

Desirable structural materials are commented upon, such as truss spans, brick or concrete for walls, plastered wall for waiting rooms, office and staff rooms, and cement for floors.

Numerous advantageous features are mentioned in connection with height of ceilings, roof design, and mechanical operators either hand or motor-driven for opening and closing the window sash. A method of top lighting which has proved very effective and otherwise satisfactory is illustrated and described.

Desirable types of service pit are shown in which recessed lighting, compressed-air, oil, drainage and ventilation facilities are provided. The author discusses the elimination of carbon-monoxide gas and describes heating and lighting methods, repair-shop practices and a specific modern motorcoach garage. Exterior design for attractive appearance is advocated and comments are made on motor-truck garage and service-station design.

In the discussion, the best location of the pits for servicing the vehicles is debated and statements are made concerning the best types of general illumination in a garage in connection with maintenance, inspection and repair work.

PASSENGER-CAR GARAGE design has been developed to such a point that the prospective builder may choose one of many well-tried schemes, but the garage for housing motorcoaches and motor-trucks, especially the former, presents a comparatively new problem that is of particular importance today. Because in recent years numerous corporations operating large fleets of motorcoaches and trucks for passenger and freight service have come into existence, and since motorcoach travel is growing so rapidly, the garaging and servicing of the necessary vehicles presents a problem the solution of which requires that the number and type of vehicles to be housed and the servicing they are to receive must be given prime consideration.

Motorcoaches vary in length from 27 to 32 ft. and in width from 7 to 8 ft. Their heights vary from 7½ to 9 ft., and double-deck motorcoaches, as used in many cities, are as high as 12 ft. It follows, therefore, that buildings housing such vehicles must have clear open spaces as free as possible from columns. Multiple stories are used in a number of cases; however, on the whole, the single-story structure seems preferable. One-story buildings should have a clear width of not less than 100 ft.; a width of 110 ft. is better. If multiple stories are used, and such are often required where land values are high, the 100-ft. unit is best divided, with a center space not less than 50 ft. between column centers and 25 ft. left between columns and side walls. In the opposite direction, columns should be not less than 32 ft. between centers.

The multiple-story structure necessarily presents the difficult problem of access to the upper floors. While ramps in most of the ordinary garages prove an economical solution, they are virtually impossible in the motorcoach garage, though the staggered-floor scheme should lend itself satisfactorily. The wide turning-radius of motorcoaches presents particular difficulty. The use of elevators is not favored except for reaching storage and possibly shop floors, yet it seems not impossible to use a scheme of elevators similar in plan to the Kent system where motorcoach garages must be located on restricted ground-areas and extreme height is resorted to; but this necessitates costly equipment. The simplest solution undoubtedly is the one-story building, and such have been used in the main for the newer Eastern garages.

Occasionally, a particularly favorable site presents itself, where, as in the case of the motorcoach garage of the New York Bus Co., on 155th Street, both front and rear streets are inclined sufficiently to afford at different points direct entrances to the respective floors. The ground floor is thus reached at the low point of one street and the second floor at another point; the third floor, used for storage of parts, is served by an elevator. Supervision of numerous entrances at distant points, however, necessarily becomes more difficult.

Multiple-Story Truss Construction

A building almost free of columns on the first floor, still having a second and even a third floor, is not at all impossible. Trusses spanning the entire width of 100 ft. and carrying other floors would be out of the question because of their excessive cost, but a thoroughly practical scheme might be the carrying of the trusses either above the second-floor ceiling, supporting therefrom the floor slab of the second story, or actually placing the trusses within the height of the second story. Thus located, the trusses might have center openings designed so as to afford access to the areas between the trusses. Such a design would have the advantage of clear floor-space below, where the motorcoaches are stored, and still furnish on the second and third floors

[1] Albert Kahn, Inc., architects and engineers, Detroit.

storage and service spaces in which columns are less objectionable. If, with such a design, the abutting streets were inclined and afforded direct access to the first and second floors, as mentioned, the problem of serving the upper floors would be simplified. Otherwise, either elevators or ramps could, of course, be used.

As to comparative costs, a fire-resisting multiple-story structure built of either concrete or steel, having columns in the first floor, would cost less per square foot than a one-story building if of fire-resisting construction. If fire-proofing of the structural steel were not required by the city building departments or if a wooden roof were permitted, the one-story building would cost less per square foot than the multiple-story building.

In selecting a site, the possibility of future expansion always should be kept in mind. A railroad siding, where possible, is a valuable asset, since the buying of oil and gasoline at wholesale and having it delivered directly from the cars result in a substantial saving. Congested districts should be avoided. The need for accessibility is determined by whether or not the public is to make use of the building.

Since in one-story structures, such as shown in Fig. 1, ample daylight can be introduced through monitors or skylights, side light is unnecessary; therefore inside lots, which are cheaper than corner lots, are satisfactory for these. The all-important considerations are adequate width and length. In many cities, especially in certain areas thereof, the allowable areas of buildings without fire walls are limited, particularly if the buildings are unsprinkled or non-fire-resisting. In some cities the area is limited in fire-resistive buildings even when equipped with a sprinkler system. This is a distinct hardship and it will be gratifying when city building-codes take cognizance of the facts that garages are not powder magazines and that statistics prove that fires in them are relatively infrequent. The limitations and strict requirements imposed by many of the codes are ridiculous, wasteful and unnecessarily costly.

Motorcoach Garage Construction and Cost

In planning a modern motorcoach garage, attention to a number of details will make for ease of operation and for economy in both housing and servicing motorcoaches. It seems that in buildings of this kind, where the garage portion is one-story high, a part might easily be constructed several stories high, especially that part devoted to office work, which requires considerable floor space. This plan was followed in the New York City building already mentioned, in which the offices are housed in a seven-story structure adjoining the garage.

These buildings are less costly when built with wooden roofs rather than with roofs of non-combustible materials, but it seems that the latter type, all things considered, would be the advisable one to employ. Precast cement-tile roofs supported on steel purlins have proved very satisfactory. When the roofs have sufficient pitch, the so-called interlocking tile, which needs no further waterproofing, can be used. For flat roofs pre-cast flat-slab tile and also channel tile are available, over which is laid the regular asphalt or tar-and-gravel roof. A new form of roofing developed in recent years is one of steel boards stiffened with turned-down edges, which makes a roof considerably lighter than tile and equally satisfactory, also reducing heat loss when covered with an insulating material such as Celotex before laying the roofing felt. Interior conductors always should be used for the roofs, thus preventing frosted gutters, dangerous icicles and leaky roofs. The best roof-sump we know of is that called Harco Premier.

Where intermediate columns are used, reinforced concrete will prove cheaper than fireproofed structural steel; but exposed structural steel with a non-combustible roof will be less expensive than to use all reinforced concrete. The cost of one-story buildings having no posts and depending somewhat upon the area, when of fire-resisting construction, but with the steel trusses unprotected, is from $3 to $4 per sq. ft. of area. If a wooden roof is used, the cost will be 50 cents per sq. ft. less. Multiple-story buildings of reinforced concrete will cost approximately $3 per sq. ft., and somewhat less if made of unprotected steel and having concrete floor-slabs. Naturally, many factors bear upon the cost, such as required foundations, building laws and the like. These prices are the average under normal conditions.

Desirable Structural Materials

Structural steel is the best material to use for 100-ft. spans, at least in this Country where the cost of form work for reinforced concrete is so great; but abroad many wide-span structures are built in reinforced concrete. Either brick or concrete is satisfactory for walls. For waiting rooms, office and staff rooms, the walls would best be plastered, though the use of salt-glazed brick produces excellent results economically. Cement is generally used for floors. Cement floors are less likely to crack when slightly reinforced with steel mesh than when reinforcement is omitted. Various hardeners used in the composition assist in making the floor surface tougher and less dusty. The best floor finish, however, which has come to my attention is a method only recently introduced, in which granite chips are used for the aggregate, the floor being floated true and smooth to established grades, and then ground with a floor grinder. This process leaves the floor clean and absolutely dustless, although it costs 7 or 8 cents per sq. ft. additional. The cutting of floor slabs into squares, as for sidewalks, is

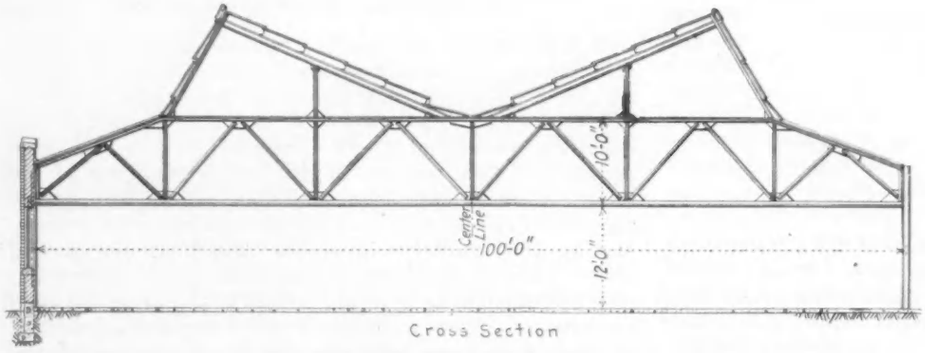


FIG. 1—ROOF DESIGN OF ONE-STORY GARAGE EQUIPPED WITH TOP LIGHTING

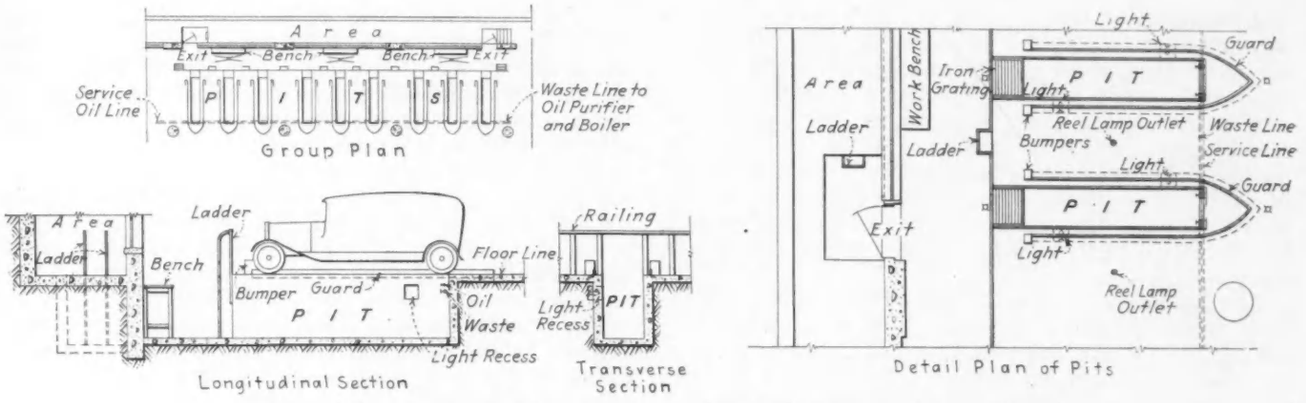


FIG. 2—DETAIL PLAN OF SERVICING PITS, SHOWING GENERAL ARRANGEMENT

not desirable, since the floors begin to give way at these joints and are then quickly ruined.

Roof Design and Service Pits

A clear ceiling-height of 11 ft. is adequate for ordinary motorcoaches, but for double-deck motorcoaches not less than 14 ft. is required. The roof design is important, especially where motorcoach garages are on inside lots and top light must be provided. The ordinary skylight is likely to leak and generally gives trouble after a time. A system of vertical or slightly inclined lighting is therefore to be preferred and an ample number of pivoted or top-hung ventilators must be provided. Steel sash are greatly to be preferred to wood. A number of satisfactory makes of such sash are now to be had at a cost little, if any, higher than wooden sash. All manufacturers furnish mechanical operators, either hand or motor driven, for opening and closing these sash.

A method of top-lighting which has proved very effective and otherwise satisfactory as used in a number of our industrial plants is indicated in Fig. 1. Side-lighting is desirable, where possible, although even then top-lighting is very essential in the necessarily wide center floor-spaces. For side-lighting as well as top lighting, the steel sash are much to be preferred to the wood sash. Window sash in side walls would best be 4 ft. or more above the floor level and should be carried up between the trusses as high as possible.

Desirable types of service pit are shown in Figs. 2, 3 and 4. It will be observed that recessed lighting, compressed air, oil and drainage are provided and that ventilation is taken care of mechanically. These pits are a great convenience and must be properly constructed for the most efficient servicing of cars. Entrance doors of the size required by motorcoach garages are necessarily a detail which can give much trouble. The hardware for them must be of perfect design and construction. That which has served us best is manufactured by the R. V. Harty Co. in Detroit. The doors are best operated by electric or pneumatic operators.

Elimination of Carbon-Monoxide Gas

The elimination of exhaust gas in a motorcoach garage or repair shop in cold weather has been a real problem. The periodic opening of doors and windows to remove the gases is only a temporary expedient and is very expensive because of heat loss. Exhaustive experimentation with ozone has been carried on but this method has been dropped because it was found very difficult to control the quantity of ozone required and to properly distribute it. Ozone does not, of itself, neutralize the carbon-monoxide gas but its effects upon the occupants of the building are believed to neutralize the detrimental effects of carbon-monoxide gas.

The blue smoke emitted from exhaust pipes is not at all injurious, although sometimes it is nauseating; usually it rises and can easily be exhausted through roof ventilators or high transom windows. The deadly carbon-monoxide gas, which is invisible and odorless, settles to the floor and has been coped with most successfully by installing underground ducts to gradually carry off the lower stratum of air. For general clearing of this gas 12-in. grill floor-openings have been found to be sufficient, but all underground piping must be of ample size to carry a sufficient quantity of air at low velocity. This is very important because it has been found that, when high velocities are used in exhaust systems, the ventilation is very spotty, a large amount of air being drawn only from the immediate vicinity of the opening and usually taking with it a considerable quantity from the higher strata of air and causing a resultant heat-loss. The lower velocities in the larger openings give a good slow but steady flow of air to the ducts. A system laid out to give three air changes per hour has been found adequate in actual practice.

In shop areas where engines are being tuned up or run more than 10 min. at a time we attach special fittings, located flush with the floor, to the underground duct. A flexible tube is then slipped over the end of the exhaust pipe of the motorcoach and the other end of the tube attached to the fixture in the floor, so that the exhaust gas is carried outside of the building. Particular care must be exercised to exhaust fumes from repair pits, as dangerous gases accumulate in these low areas.

Effective and Economical Heating Methods

Either steam or hot water may be used for heating the garage building. The heating plant must be accessible only from the outside of the building. A temperature of 60 deg. fahr. is adequate for the garage portions, and the heat may be supplied by unit heaters, radiators, or pipe coils at the walls near the monitors or skylights. For the office portion, direct radiation to provide 70 deg. of heat in zero weather must be supplied.

Unit heaters are the most economical method of heat-

ing buildings of this type, and they have the further advantage of keeping the floor area entirely clear. They also lend themselves readily to changes in use of the area and permit making outside-air connections that aid in ventilating those portions of the building in which gases might accumulate to an objectionable amount. An important consideration is that the intake of unit heaters in all cases be high enough above the floor to prevent drawing in the exhaust gases from near the floor and redistributing them through the entire room.

The installing of special unit-heaters about 15 ft. back from the doors, to direct a blast of warm air against the opening, has been found advisable in garages in which the doors are opened frequently on account of the schedule of arriving and departing motorcoaches. This warm air mixes with the cold air blown into the garage and makes unnecessary the objectionable periodic cooling. Mercoid thermostatic controls can be provided for the unit heaters at a slight additional cost. These will shut off the heaters at any predetermined temperature and result in a saving of steam. The installing of a separate main for heating the offices is desirable from the viewpoint of economy, since heat will be required in this part of the building at times when it is not necessary in the garage itself. During these periods the steam mains supplying the garage can be shut off.

Lighting, Washing and Sprinkler Systems

Only the simplest form of lighting is required for the storage area of the garage, but particular attention should be paid to the method of lighting and switching off the lights in the driving aisles. Lights in the storage area can be controlled from a conveniently located switch-panel board. The lighting in the shop area must be carefully planned so that working lights are located directly over the benches and the engines. Convenience outlets suspended from the ceiling should be provided between each two repair stalls to reduce to the minimum the spreading of wires on the floor.

The lighting of wash racks has been a subject of much study. A simple, satisfactory method is to provide two longitudinal bars, one on each side of the vehicle to be washed, equipped with angle reflectors at about 4-ft. intervals. These bars are suspended from the ceiling about 8 ft. above the floor. In some instances flush-type recessed reflectors, at a low elevation to illuminate the underside of the running gear, can be used.

Wash racks have been modernized through the use of high-pressure washing-machines which boost the available city-water pressure up to 200 to 300 lb. per sq. in. This equipment materially speeds up the washing of chassis. The high-pressure nozzles can be used also for cleaning the engine and any greasy parts as units are being dismantled in the shops. The use of compressed air for drying around the engine is necessary after the engine has been cleaned with a high-pressure water-gun. Compressed air can also be used satisfactorily for blowing excess water off of the vehicle windows and for drying the entire body.

The installation of a sprinkler system is determined entirely by the particular conditions of each case. The necessity for such a system is decided by local fire-ordinances and by the return on the investment resulting from the reduction of insurance premiums. Sprinkler systems are sometimes installed to permit the construction of larger areas between fire walls. Fire-protection devices such as sand pails, portable extinguishers and other equipment are the same in these garages as in the ordinary storage garage. The regulations of the National Board of Fire Underwriters fully cover protection of this nature.

Repair-Shop Provisions

Necessary provision should be made to carry a trolley beam along the shop area about 10 ft. from the inside wall for use in hoisting engines and lifting the front of motorcoaches when working underneath the engines or around the front axle and steering connections. It is important that care be taken in the design of the building to provide for this, because the load imposed upon the trusses carrying the trolley beam is very heavy and special structural strength is usually necessary.

Congestion along the front of the repair shop where benches are located has been largely remedied by reducing the amount of bench space to one-half of the aisle length accommodated; in other words, as much blank space as bench space is provided along the wall. This gives the workmen a chance to place jacks, pails, bonnets and the like against the wall and out of the aisle. Compressed-air outlets are provided for each bench, and each outlet at this location is equipped with a hose long enough to reach to any part of the motorcoach.

As the life of pneumatic tires, especially those on heavy motorcoaches, depends on maintaining the recommended air pressures, numerous compressed-air outlets

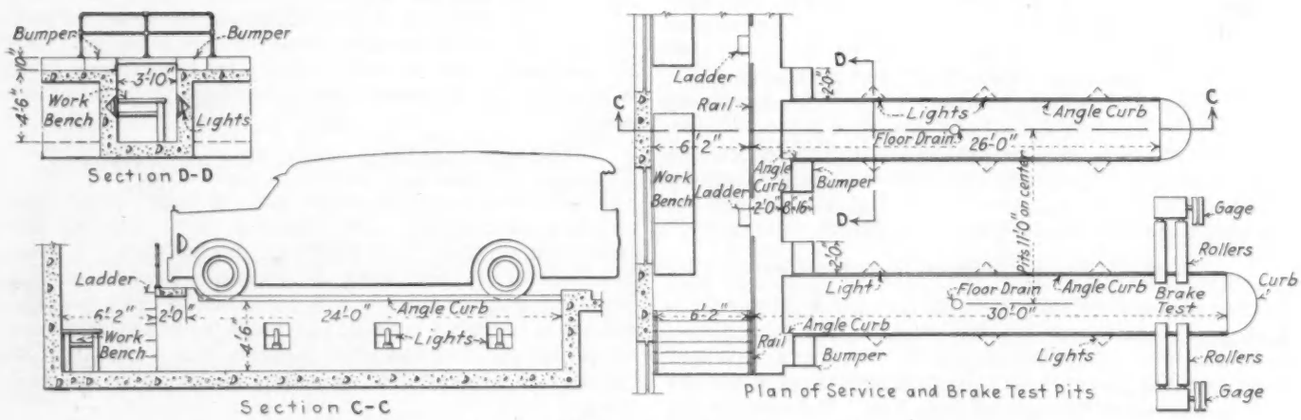


FIG. 3—PLAN AND VERTICAL SECTIONS OF SERVICE AND BRAKE-TESTING PITS

should also be provided along the aisles for inflating tires. A special hose-reel is desirable at each of these points to keep the hose off the floor; otherwise it would be damaged.

Gasoline should be handled by the metered pressure-system. Engine, transmission and rear-axle oils can now be efficiently handled in a similar manner. Water is supplied by a long hose on a self-winding reel, with a self-closing faucet at the end.

Drainage of the floor must be properly arranged. A good plan is to install a shallow gutter, 12 in. wide and about 30 ft. from the side walls, extending the entire length of the garage and shop and to cover it with iron gratings made removable to permit cleaning. The central floor space, as well as that between gutter and side walls, should be slightly pitched to the gutters, and these should have adequate fall to the outlets. Special sumps must be supplied for the wash racks. Two sections of 24-in. crock covered with removable grating serve adequately.

So-called white industrial enamel is the most satisfactory material for painting walls and ceilings, an item not to be overlooked and which adds greatly to the clean appearance of the garage. It is best to spray it on, where this is permitted by labor unions; otherwise it can be applied with a brush. A dado of darker color, 4 ft. high, is desirable, with a black line to finish off.

A Modern Motorcoach Garage

The best motorcoach garage that has come under my observation is one recently completed in Detroit for the Greyhound line, through the courtesy of which a number of successful details incorporated therein are given here. This garage is 115 ft. wide over-all and 379 ft. deep. It houses 50 motorcoaches and affords in addition adequate space for a reasonable amount of servicing. The main shop of the company is elsewhere. There are four doorways in the front, two for entrance and two for exit; and all are opened and closed by electrically operated devices.

Immediately inside of the entrance doorways, wash racks are provided for cleaning the vehicles. These have overhead sprays for hot water and a platform for manual washing. The method of washing employs a soap solution under pressure of 300 lb. per sq. in. obtained from a motor-driven triplex pump. The entire motorcoach is sprayed with this soap solution. It is then scrubbed with brushes and rinsed with spray heads located in rectangular rings above and at the sides of the vehicle. The water drains to a gutter on each side covered with a removable grating. Directly beyond the wash racks are two pits, 30 ft. long, 46 in. wide and 4 ft. 6 in. deep, for oiling and greasing the chassis and filling the tanks.

Oil Storage and Distribution

The oil-handling and storage system is located in the basement and includes four 1000-gal. tanks, three oil-pumps, one pneumatic grease-gun, one pneumatic heavy-oil gun and a filtering system. The heavy oil and grease are delivered to the pits for chassis lubrication by compressed air. Two of the four 1000-gal. storage tanks are for storage of new engine-oil, one is for storage of filtered reclaimed oil, and one is for the storage of unfiltered reclaimed oil, which is pumped from the tank through a filter and delivered to the filtered-oil tank. The new and the filtered reclaimed oil are distributed by pumps from storage tanks on the first floor. The oil is filtered through an ordinary filter. Gasoline is supplied to the pits by means of four motor-driven gasoline pumps drawing from three underground tanks.

The wash racks as well as the grease pits are enclosed on one side by a steel-and-glass partition. On the opposite side is located the general office, with toilet and vault, and close to the grease pits is space for storage of tires, so that tires can be changed while greasing is

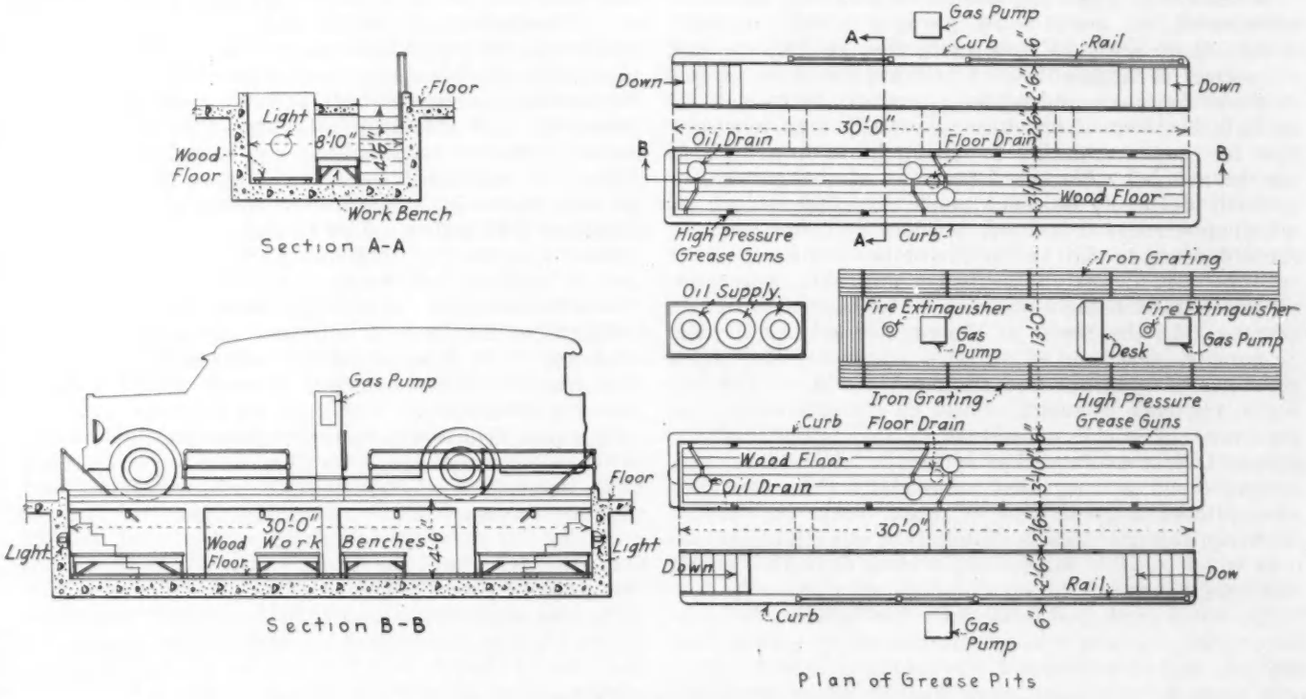


FIG. 4—PLAN AND VERTICAL SECTIONS OF GREASING PITS

being done. Above the wash racks a mezzanine space is provided for storage of baggage, which is transferred by hand from the top of the coach.

After the motorcoach is washed, greased and filled, it is taken to a pit at one side of the garage and given a brake test. The brake-test pit is one of seven pits located at one side of the garage, all opening into a connecting header-pit parallel to the wall. Work benches are located in this header-pit. Each pit is approximately 5 ft. deep, 30 ft. long and 46 in. wide. They are spaced 11 ft. between centers and illuminated on both sides with vapor-proof globes recessed into the concrete sidewalls. Air is exhausted from the bottom at one end of each pit.

The coaches are carefully examined each time they enter the garage, are attended to and thereafter are stored ready for the next trip. Separate rooms are provided for the battery work and for steam cleaning. In the rear of the garage is a general stock-room, one for engine repairs, one used as a paint shop for mere touching up, and a body shop for minor repairs.

The superintendent's office and the dispatcher's space are located at the side of the Detroit garage.

This garage is merely one of a number of branch terminals and has operating-crew accommodations consisting of an ample-sized drivers' room and rest and toilet rooms. More complete accommodations are provided at the Chicago headquarters, which contains a drivers' recreation room equipped with pool tables, a lunch counter, locker rooms, sleeping quarters with baths, a tailor shop for cleaning, pressing and repairing of uniforms, a barber shop and a shoeshining stand. Everything is provided that encourages cleanliness and neatness of appearance of the operating crew. Such conveniences have a wholesome effect upon the morale of the employes.

Exterior Design for Attractive Appearance

A feature of great importance in the construction of motorcoach or motor-truck garages is the exterior design, there being no reason why they should not have an attractive appearance. Little argument is needed to prove that a neighborhood can easily be ruined by an ugly building of any kind, especially a garage, and that by proper attention to design harm to a district can be avoided. Nor need the cost of the garage, if properly designed, be much more than that of one in which appearance is ignored. Appearance merely reflects the difference in skill of the respective architects.

Simplicity of design is always desirable, expensive ornamentation being unnecessary for a well-designed exterior. In the hands of the capable architect, good proportion, selection of suitable materials, the right grouping of openings and the mere outline of the exterior are made to count. These do not involve the expenditure of much additional money. The modern garage is just another type of industrial building, and no one would gainsay that industrial architecture has accomplished a great deal in recent years in making formerly objectionable buildings into attractive structures which add to rather than detract from the immediate neighborhood.

The same care bestowed upon the building by the motorcoach operator will prove an asset just as do the neatness and cleanliness of his operating crew. Common sense dictates that there must be added prestige, and satisfaction in building not only well but attractively. Good-looking motorcoach garages must increase the confidence of the public and promote a feeling of solidity and safety, which are important assets to any company operating motorcoaches just as they are to other industrial concerns. No one today appreciates more than the owner of an industrial plant how valuable is the public's appreciation of well-designed and orderly buildings, as well as their good effect on the morale of his employes.

Motorcoach and motor-truck operation is bound to grow larger and more important as a means of passenger and freight transportation. It is to be hoped that the heads of operating companies will equally realize the value of appropriate buildings in their field of activity.

Truck Garage and Service-Station Design

The motor-truck garage, if for operating a fleet of trucks, might well have the same accommodations as a motorcoach garage except for the public waiting-rooms and dispatcher's station. As for dealers' sales and service buildings, certain details previously mentioned might apply, at least to the service portion of such buildings. The salesrooms in the latter are an added essential. Good show-windows, adequate public entrances, the necessary executive and sales offices and the like are required. These problems, however, have been solved many times and their solutions are too well known to require particular treatment herein.

The importance of entrusting the design of motorcoach or motor-truck garages to a thoroughly qualified concern is emphasized. A concern having experience and completeness of organization will avoid mistakes, seek the simplest solution of the problem, effect economies in both construction and cost of maintenance, and produce practical as well as architectural results worth many times the fee paid for such service. Too often the designing and erecting of buildings of this type are entrusted directly to builders or to fabricating engineers, in the belief that money is saved thereby. The possibility of obtaining competitive bids from equally responsible concerns, which is made possible by complete plans and specifications prepared by an architect, seems sufficient reason for employing an architect. Bids from accurate plans often vary 10 to 20 per cent for one reason or another, even among thoroughly responsible contractors. The saving thereby effected as against accepting any one man's price easily covers the cost of architectural service.

Aside from this, however, it must be obvious that builders can hardly keep informed on matters of planning any more than architects can on the latest and most economical management of work in the field. I realize that there are architects who think of exterior appearance first and practical results last. There are, however, firms that are thoroughly alive to efficient planning, economical construction, the employment of correct business methods for carrying on the work and the necessity for careful supervision of the work. These firms will safeguard the owner's interests in every way and produce thoroughly workable, efficient and at the same time architecturally creditable results. The builder of the modern motorcoach or motor-truck garage can do no better than to bear this fact clearly in mind when contemplating the erection of such a structure.

THE DISCUSSION

A. J. SCAIFE[2]:—What is the best location for the pit? Mr. Hewitt had some ideas with regard to locating the pit near the outside wall of the building and having an outside entrance instead of locating the pit in the middle of the building.

H. B. HEWITT[3]:—We are now using three types of pit. In the garages we locate a row of pits along the windows and try to select a site where the pit side of the building will be above the street level so that natural ventilation is provided. This means that the garage entrance would be from one street and the street or ground level back of the garage would be somewhat lower, the pit floor being almost on the street level, so that windows can be provided all the way down to the work benches. This construction is very satisfactory. In the garages for motorcoaches we installed two pits along the wall, set at about a 35-deg. angle with the wall, somewhat like the way cars are parked along a curb. The pits are ventilated in groups of three, which was the restriction made by the insurance department.

In the general shops we have a continuous pit from one end of the shop to the other. This is a combination pit which we use for both cabs and motorcoaches. We find that production is forced if we put a good lively crew at the beginning of the pit and keep pushing the vehicles along until they come out at the other end, there being no other way of getting them out except by using plank runways or lifting them out with a crane.

QUESTION:—What special types of light and special distribution of lighting fixtures have been developed? The question refers to general illumination in a garage in connection with maintenance, inspection and repair work.

S. R. DRESSER[4]:—We have had some experience with mercury-vapor lights in the washing department of our garages, believing that these would eliminate shadows, but we are now getting practically shadowless illumination with ceiling lights of sufficient intensity which diffuse the light well. One difficulty relates to the wash floors themselves. A wet concrete floor does not reflect much light. Another factor of importance is that the light in the garage interior must be sufficiently intense so that people driving in from a sunlit street are not blinded by the darkness. I believe that, on service floors, satisfactory distribution of light can be obtained from overhead fixtures and that they can be arranged to provide practically shadowless illumination.

[2] M.S.A.E.—Consulting field engineer, White Motor Co., Cleveland.

[3] Assistant to vice-president of operation, Mitten Management, Inc., Philadelphia.

[4] M.S.A.E.—Executive engineer, Kent Garage Companies, New York City.

Small Airplane-Engines

(*Concluded from p.* 351)

run at high speed without propellers and are very quiet when muffled.

W. E. POWELSON[7]:—What progress is being made along the line of extinguishing fire in airplanes?

MR. TILLEY:—One of the major developments was to place the inlet of the carbureter outside of the engine compartment, so that in case of a backfire the flame went out where it did not make any difference; that is, an air stack was put on the carbureter so that the whole fuel-induction system was inclosed. On many Government airplanes, a fire-extinguishing system is operated from the dash. In cases that I happen to know of, in which men jumped because their airplanes caught fire, apparently they never used it; they did not wait. Possibly, under the same circumstances, we would have done the same. Very often fire extinguishers are placed on the outside of the airplane, so that, in the event of a crash, the first person to reach the scene can use them, as the people inside cannot get out.

MR. POWELSON:—Is Pyrene used for those extinguishers?

MR. TILLEY:—The extinguisher is a pressure type operated by punching a button. I do not know whether carbonic acid gas or Pyrene is used.

Factors Limiting Crankshaft Speed

QUESTION:—Disregarding propeller efficiency, what factors limit crankshaft speed in the type of engines you have discussed?

MR. TILLEY:—Propeller efficiency is very often disregarded in the effort to get high power, and the limiting factor then is whether the engine will stay together. If these engines are run at 20 or 40 per cent overspeed, they will not last very long; something will let go. The normal development of an aircraft engine is to run an overspeed test, observe what lets go, make the proper correction and then do the same thing over, at a higher speed.

A MEMBER:—Is incorporating a diffusion chamber in the light-weight engine and taking advantage of the pressure rise that would be available due to that crankshaft speed general practice, and does any advantage result from including this chamber when a fan running at crankshaft speed is applied, or must some special precaution be taken to regain the pressure rise that you would have?

MR. TILLEY:—A large-diameter impeller gives high peripheral speed. To obtain pressure rise efficiently, a diffusion chamber is required which may consist of vanes or a space of several inches between the impeller periphery and the outer diameter of the chamber where the outlets are. This forms a chamber of increasing area as the air passes from the periphery of the wheel to the outlets for the cylinders.

A MEMBER:—Is that system used primarily to increase the pressure to the carbureter or to secure even distribution in the radial type?

MR. TILLEY:—It is done for both reasons. In the crankshaft-speed type, however, distribution is sought rather than the pressure rise.

[7] Master mechanic, Los Angeles County, Los Angeles.

Modern Motor-Truck Bodies

By JOHN WALKER[1]

TRANSPORTATION MEETING PAPER — *Illustrated with* DRAWINGS AND PHOTOGRAPHS

COMMERCIAL-VEHICLE bodies are divided by the author into two general groups: the standard bodies offered for sale complete as a unit with the chassis by the truck manufacturer, and custom-built bodies ordered separately by the purchasers of truck chassis. The former are planned by the chassis company's engineering department to secure correct load distribution, light weight and attractive appearance. Custom bodies, however, are often built by small local body-builders or even by the chassis purchasers, who frequently disregard simple engineering features and construct bodies that are too long for the wheelbase, with the result that the load is improperly distributed between the front and the rear axles. As a consequence, the rear tires are overloaded, larger tires are necessitated and the customer is dissatisfied.

Close cooperation between the manufacturer's engineering and sales departments is needed in the selling of trucks, to assure that the capacity and wheelbase will be correct for the body size that is required, so that the load will be distributed properly. The tires chosen for the vehicle should also be adequate.

Some examples of aluminum bodies, which reduce the dead weight and enable the chassis to carry more pay-load within the maximum-weight restrictions of various States, are given, and methods of mounting tank and motorcoach bodies flexibly on the chassis are illustrated and described.

In the discussion, suggestions are made that operators would benefit a great deal if the truck companies would give more attention to training their local service organizations in some of the engineering requirements so that they could advise purchasers more intelligently. Most of the discussion relates to the straight-rating policy adopted in 1928 by a leading truck manufacturing company, and an earnest plea is made for the standardizing of the chassis dimension from the back of the cab to the center line of the rear axle and of body lengths suitable for a standardized range of such load spaces. Such standardization is said to depend entirely upon the willingness of the truck industry to approve the idea and cooperate in formulating and following such standards.

COMMERCIAL bodies are beginning to receive some much-needed consideration aiming at balanced design of truck and body as a unit to suit particular requirements. There remain, however, the problems of proper load distribution, reduction of weight, flexible mountings and good appearance; and if we divide commercial bodies into two general groups we shall see why this is so.

In recent years several manufacturing companies have offered their chassis for sale complete with various standard bodies of the closed, rack and express types. As these trucks were planned to be built on a production basis, the manufacturers' engineering departments secured correct load distribution, light weight and attractive proportions, so that all that the sales departments had to do was to sell them.

Conditions are not so clearly defined in the second group, that of custom-built bodies. Virtually all trucks of 1½-ton capacity and larger have such bodies. Local body-builders are called upon by the purchaser of the chassis to build a body to certain specifications. Often, distribution of load receives little, if any, consideration. This situation was not excessively serious while solid tires were still in common use, but now when pneumatics are almost universal equipment, even on the largest trucks, it is of prime importance. Again, the weight of custom-built bodies is generally excessive and the method of their mounting remains unimproved. Good appearance, while admittedly desirable, is often expected without additional cost and consequently remains somewhat neglected. As such custom-built bodies are frequently made by small body-builders or by the chassis purchasers themselves, the engineering department of the truck manufacturer loses its direct contact. These problems may not be very difficult from the engineering point of view, but from the sales standpoint they are real enough.

Calculating Load Distribution

Let us consider for a moment the way in which trucks are sold. Assume, for example, that the salesman has convinced the prospective buyer of the merits of the truck and decides that the purchaser should have a 2½ to 3-ton chassis. When the customer asks about the tires to be used on the truck, he is told they are 38x7-in. single front and the same size dual rear tires. Since the body is to weigh not more than 3500 lb., the truck 6800 lb., and the load 8900 lb.—a total gross weight of 19,200 lb.—it is decided that such a tire equipment is adequate because six 38x7-in. tires have a combined capacity of 19,200 lb. So far, the estimated gross weight and total tire capacity agree; but will the customer buy a body that distributes the load properly on the six tires? If he buys a chassis having a standard 164½-in. wheelbase with a 12-ft. platform and orders a body which is 13 ft. long, the resulting load distribution will be very poor, because the rear tires will be 17 per cent overloaded, as indicated at the left in Fig. 1. When the tire salesman is consulted, he immediately recommends larger tires. This advice is sound but puts the customer to extra expense and necessitates delay, making him dissatisfied with his purchase. If I assume in this case that larger tires cannot be put on the truck, the owner must reduce his pay-load by 2100 lb., which condition further dissatisfies him.

Had truck salesman and the customer discussed load

[1] Engineer, special equipment, Mack-International Motor Truck Corp., New York City.

and body size and given thought to the proper distribution of that load, they would have discovered that a 200½-in. wheelbase chassis would be necessary with a 13-ft. body to take full advantage of the rated tire capacity, as shown at the right in Fig. 1. But before choosing this as the correct wheelbase, two alternatives should be considered: whether it is better to load the tires equally by using the 200½-in. wheelbase or to compromise on the wheelbase and slightly overload the rear tires. The longer wheelbase certainly makes the vehicles more difficult to handle. Overloading of pneumatic tires not in excess of 10 per cent is not necessarily serious, but the tire man should always be consulted in such cases. For this reason I believe that the second alternative would undoubtedly be the better one and would permit the use of a wheelbase somewhere between the two lengths mentioned.

All such calculations are based on the assumption of a uniform load, a premise that may or may not hold true in every case. The point I desire to make is that, in selling trucks, we should first determine the desired body size and loads to be carried and then sell a chassis of the correct wheelbase and capacity. Last, but not least, the pneumatic tires chosen for the vehicle must be adequate. To assure this condition, better cooperation than is now common between the sales and engineering departments is required. It is easy to give the salesmen data and formulas to use, but few salesmen will trust themselves with any engineering formula. After all, a salesman's job is to sell the truck, and an engineering department's function is to help him sell it properly.

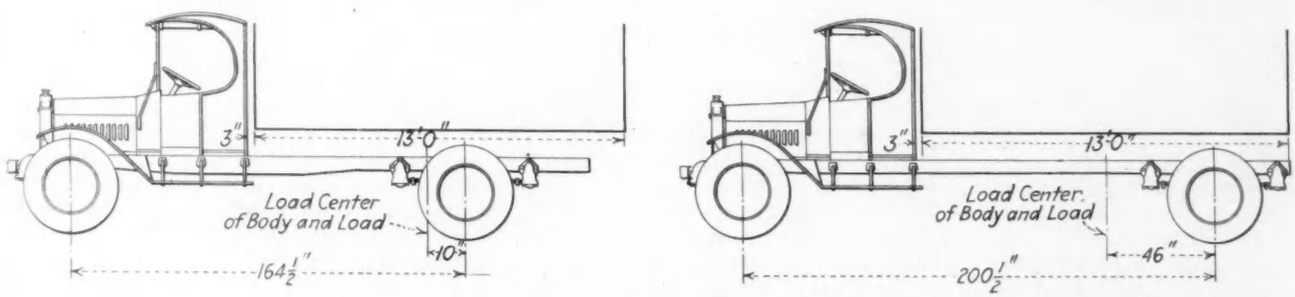


FIG. 1—WRONG AND RIGHT DISTRIBUTION OF LOAD WITH 13-FT. BODY, SHOWING TOO-SHORT AND CORRECT WHEELBASE

Data of Both Trucks: Rated Capacity 2½ to 3 Tons; Tires, Six 38 x 7-In. Pneumatic, with Capacity of 19,200 Lb.; Body Length, 13 Ft.

LOAD DISTRIBUTION ON TIRES

Weight of		164½-In. Wheelbase Front	164½-In. Wheelbase Rear	200½-In. Wheelbase Front	200½-In. Wheelbase Rear
Chassis, lb.	6,800	3,550	3,250	3,600	3,300
Body, complete, lb.	3,500	210	3,290	800	2,700
Pay-Load, lb.	8,900	540	8,360	2,000	6,800
Gross, lb.	19,200	4,300	14,900	6,400	12,800
Tire Capacity, lb.	19,200	6,400	12,800	6,400	12,800
Overload, lb.			2,100		None
Overload, per cent			17		None

I have cited only one example, but in the case of six-wheel vehicles and semi-trailers correct calculation is even more important and is more difficult for the sales department.

Aluminum Bodies Reduce Weight

Gross-weight limits vary widely in different States, so that at times it is difficult to build the body light yet strong enough to carry the desired load. But we must respect these laws and it is economically important that the vehicle shall carry a pay-load rather than excessive body-weight.

Aluminum bodies best illustrate the advantage of reduced body-weight. The high-lift bodies used by the Pittsburgh Coal Co., shown in Fig. 2, are made entirely of steel and aluminum. They are mounted on AB 2½ to 3-ton Mack chassis and the gross vehicle weight is just within the Pennsylvania W-class license for 22,000 lb. By making these bodies of duralumin, the weight was reduced 1800 lb. so that 5-ton loads could be hauled, as compared with the 4-ton loads carried in the all-steel bodies. The latter were made from 8-gage metal; the dural bodies had 6-gage sides and 5-gage floors.

The Motor Haulage Co. of Brooklyn, N. Y., had a semi-trailer unit built for hauling dressed hogs. This equipment is shown in Figs. 3 and 4. The entire van body is made of aluminum, dural sheets and extruded sections, special alloy castings being used. This body, which is 25 ft. long, 8 ft. wide, and 7 ft. 6 in. high, weighs only 5800 lb. A body of the same size, executed in composite wood and steel construction, would have weighed 8700 lb., or 50 per cent more. In this case the aluminum body made it possible to keep the gross weight of the vehicle within the law.

Briefly, the use of all-aluminum body construction means a saving of 40 to 50 per cent in weight, at 1.6 to 1.9 times the cost of all-steel construction. Yet the life of these bodies seems to be as great as that of other types for custom-built bodies, and their resale or scrap value is considerably higher. I believe that, for custom-built bodies, composite construction of aluminum, wood and steel will reduce the initial cost and still make possible a substantial saving in weight.

Flexible mounting of bodies and cabs still requires considerable development. This fact was forcibly brought to mind recently by one of our customers, who said that he experienced considerable frame breakage with van bodies. We all like to defend our frame construction by asserting that the trouble is caused by overloading; and, not wanting to be different, I, too, believed that this was the cause of much of his trouble. However, it seems that when these bodies were clamped tight to the chassis the trouble was more pronounced than when the clamps were loose. A rigid body on a flexible frame is bound to cause some trouble; even the so-called rigid frame construction is rigid only relatively.

We have tried the supporting of tanks on rubber mountings, as shown in Fig. 5, a method that proved very

satisfactory, although it is somewhat expensive and not easy to apply on bodies of some types. Tanks have also been mounted on three points, but the successful application of this idea seems to be limited to tank bodies that are of rigid construction.

The mounting of motorcoach bodies, being further developed than that of commercial bodies, points the way toward some good solutions of this problem. For example, we have tried the use of flexible joints of fabric and rubber between the cowl and body. This construction was of some help but spoiled the appearance of the body and left about 4 ft. of the front end overhanging from its main support on the chassis. Our latest construction method, which is very effective, is to build the entire body-shell and cowl on a steel base, illustrated in Fig. 6. This base is attached to the chassis at the rear but is allowed to float in rubber blocks at the front end. These blocks are shown supported on brackets extending out from the side-frame in Fig. 7. Maintenance of both body and chassis can be reduced appreciably by using a good flexible mounting which, I believe, is not receiving the attention it deserves.

Demand for Good Appearance

Attractive appearance is a factor that has tremendous advertising value and must be considered, whether we are building a dump truck or a van. Public-utility companies, department stores, moving concerns and dump-truck operators are all demanding better-looking vehicles, even if only the cab is improved. To discuss this phase at length would require a separate paper.

In conclusion, I want to reiterate the importance of correct load distribution and the need for cooperation between sales and engineering departments to achieve it, the possibilities of lighter bodies and cabs, the value of flexible mountings, and the relation of these things to the attaining of well-balanced and good-looking commercial motor-vehicles.

THE DISCUSSION

J. F. WINCHESTER[2]:—I would like to confirm some of the statements made by the various speakers at this session regarding the rapid wear between the body and the chassis. This condition is set up in many cases because the proper relation is not maintained from a standpoint of load distribution between the two units.

This is brought about in many instances because original bodies are transferred from one chassis to another without due regard being given to this important consideration. The result is that the body and chassis are subject to a great deal more shock than is necessary. In our operation we have done considerable experimental work on body suspension. Only a few weeks ago one of our men suggested that if we were going to use aluminum bodies we give careful consideration to using the type of rubber shock-absorber mounting Mr. Walker has described. We have had such a unit in operation for a period of 2½ to 3 years and know that the upkeep on that particular body is considerably lower than on some of the others where the mounting was of the rigid type.

Should Train Service Men in Engineering

One phase of the maintenance or service situation that could well be given closer attention by manufacturers than it has received in the past was suggested to my mind by Mr. Walker's reference to the relation of the engineering, sales and service departments to the operator. I do not understand why large companies, in the majority of cases, permit or countenance the procedure that has been described by Mr. Walker. It is true the organizations have to sell their trucks to exist, but thorough cooperation among the different departments in their relation to the operator, if studied by a well-balanced concern along the line of giving practical training to its service men in the engineering fundamentals which it advocates, would result in the solving by the local service man of many of the points that are raised. This would pay in the long run; first, from a monetary standpoint as regards the operation of the organization, and, second, from a standpoint of service directly chargeable to sales promotion.

[2] M.S.A.E.—General superintendent of motor equipment, Standard Oil Co. of N. J., Newark, N. J.

I am certain that, if many service men were better trained to handle capably their company's local engineering matters of such a nature, both the sales organization and the operators would benefit. I am inclined to believe that in many cases local service men are overloaded with work which primarily consists of taking care of the repairshop or the repair jobs that come to hand, whereas they really should be performing a broader function in the organization.

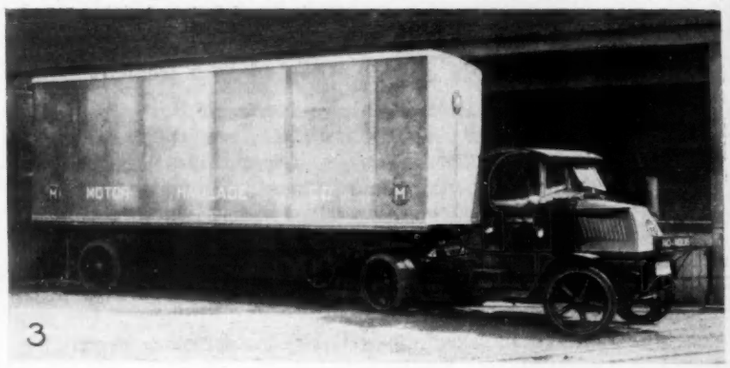
The primary object, as I see it, of a service man, if trained properly, is to serve as a direct contact or advisor to both the user and the sales department. From my observation, I know of many instances in which they work along diametrically opposite lines.

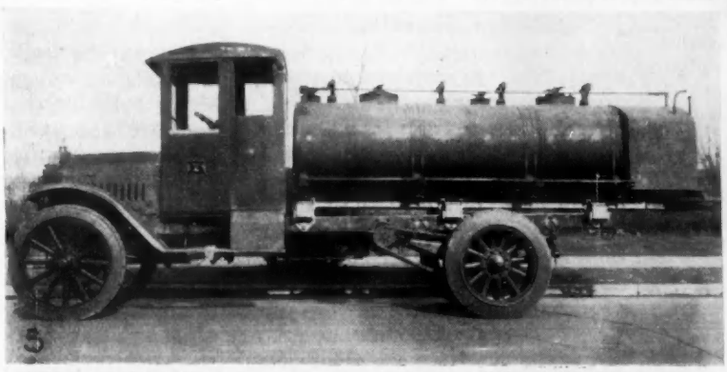
We should all be interested in modern ways of treating bodies to preserve them, for the reason that many vehicles are exported to the tropics to be operated where climatic conditions place a very severe handicap on any wood that is untreated; and our company has found that, when the vehicles are placed in such climates without the materials being properly cared for, the sills are destroyed at a rapid rate by the changed atmospheric conditions and by insects that eat into the wood rapidly. If manufacturers who ship equipment to such places would pay attention to the treating of the wooden construction, I believe the bodies would have much longer life than they have at the present.

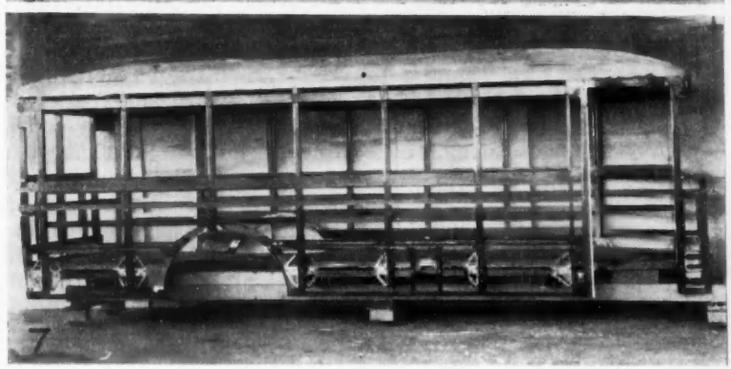
Service Men Could Help Sales

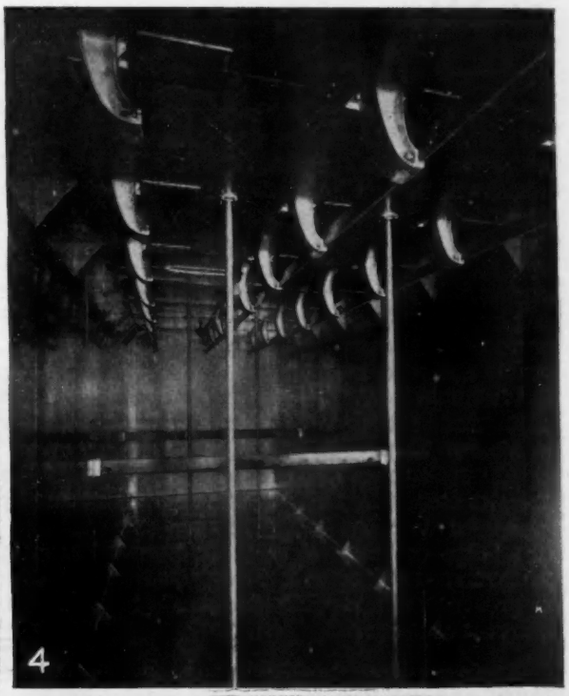
JOHN WALKER:—The point I wanted to emphasize is that the small builder who constructs a body often overlooks the factors of load distribution and body mounting, and then we hear about wrong sized tires or that the chassis is no good, or almost anything but the fact that the builder has not designed the body properly. I am not sure that I know the solution of the problem. Perhaps we can try Mr. Winchester's suggestion and help ourselves.

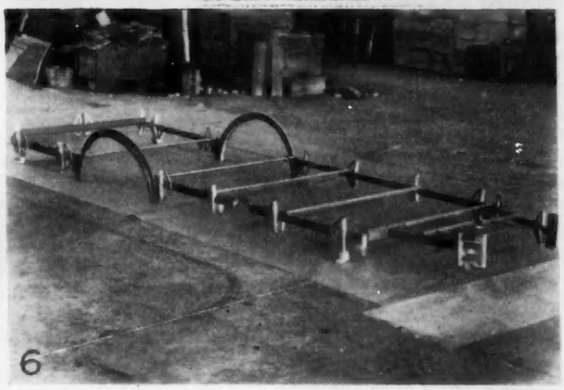
MR. WINCHESTER:—I believe that many bodies are custom built because a man in a given locality gains a reputation for doing that kind of work well and the local operator likes to be guided to some extent by a specialist in such a line who is located near him. This again goes

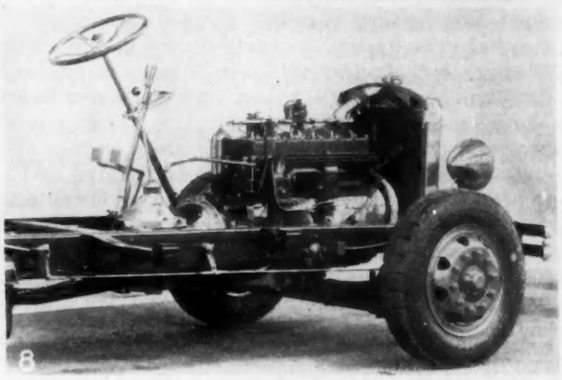












LIGHT-WEIGHT ALUMINUM BODIES AND RUBBER-MOUNTED TANK AND MOTORCOACH BODIES

Fig. 2—High-Lift Coal Body Made Entirely of Steel and Duralumin, Mounted on 2½ to 3-Ton Chassis. Gross Weight of Chassis, Body and Load Is Just within Pennsylvania W-Class License for 22,000 Lb. The Reduction of Body Weight by 1800 Lb. Enables the Coal Company to Carry 5-Ton Loads instead of 4-Ton Loads formerly Carried

Fig. 3—All-Aluminum Semi-Trailer Body for Hauling Dressed Hogs. Length, 25 Ft.; Width, 8 Ft.; Height, 7 Ft. 6 In.; Weight, 5800 Lb. A Body of This Size Executed in Wood and Steel, Would Weigh 8700 Lb.

Fig. 5—Flexible Tank-Mounting Using Six Rubber Shock-Insulators. This Method Has Proved Very Satisfactory but Is Somewhat Expensive and Not Easy to Apply on Bodies of Some Types

Fig. 7—Motorcoach Body-Framing with Cowl Built Integral with the Body, Built on Steel Base Shown in Fig. 6

Fig. 4—Interior of Semi-Trailer Body Shown in Fig. 3. The Shapes and Castings Are All Made of Aluminum

Fig. 6—Steel Base on Which the Motorcoach Body Shown in Fig. 7 Is Built. This Is Supported at the Front End on Rubber Blocks Carried on Outriggers Seen on the Chassis Frame in Fig. 8

Fig. 8—Motorcoach Chassis Provided with Outriggers Rivetted to the Side-Frames. These are Fitted with Rubber Blocks Which Support and Cushion the Front End of the Steel Frame Shown in Fig. 6, on Which the Body in Fig. 7 Is Built

back to the training of the service men. If the truck manufacturer's organization, through its local representative, could spend more time studying the customer's requirements and had men of the right type to do it, the factories that manufacture a standardized line would probably find their body production increasing. The opportunity along these lines has been overlooked in the strenuous efforts to make direct sales of the chassis. It is also overlooked in the strenuous efforts to make repairs to the chassis without providing facilities for body repair and upkeep, which the manufacturer's representative himself frequently refers to some local shop for adjustment rather than attempting to make the repairs in his own shop.

PIERRE SCHON[3]:—The company I represent has taken steps to correct some of the basic evils, especially those connected with the selling of motor-trucks. A better knowledge on the part of the salesman concerning the performance ability of a motor-truck will go a long way in preventing misapplications such as have commonly occurred in the past.

Training Men for Transportation Engineering

The first essential need is along educational lines, and our export division was first in taking advantage of this by establishing a transportation engineering school, which is now in session at our factory in Pontiac, Mich. It has been in session since Oct. 1, 1929, and will be completed by the end of December. The General Motors Export Co. found it advisable to train 25 transportation engineers for overseas service, each of whom will be assigned to one of the export company's plants located in foreign countries, to act as transportation engineer for the promotion of motor-truck and motorcoach transportation.

No program of this kind has ever before been laid out by any manufacturer of commercial vehicles, and the results from this training course undoubtedly will bring most satisfactory results. Proper application of commercial vehicles will be squarely up to these men when they reach their destination in foreign countries. Their duty will be to see that motor transportation is developed along sane, practical lines. Most of these men who now are receiving thorough training are members of the Society. Eight of them have been in foreign service with the export company, some for as long as eight years, others for a shorter time. The new men have been picked from among 400 applicants for these new positions as transportation engineers. This training course covers every phase of commercial transportation and, as most of the members attending are either graduate engineers or men with many years of transportation experience as a background, the class is really more of a transportation conference than a school. The material gathered for carrying out this educational program will also be available to our domestic sales organization in the form of text and graphic charts, showing what the limits of a motor-truck chassis really are.

Let me give an example of what has happened in the past. About three months ago I was called to deal with a case in one of our western cities, where a chassis designed for a gross load of 12,000 lb. was loaded to a gross weight of 22,000 lb. This is only one of many examples of the kind of abuses the truck industry has had to contend with in the past.

In a case of this kind, the service department is called upon for assistance but is helpless in remedying the condition permanently. Service men can only replace or repair the units in the chassis that fail because of excessive overloading. They cannot remedy the real cause of the trouble. The engineer is not to blame, for he designed the vehicle to carry a load of 12,000 lb. In some cases a misapplication of this kind is partly traced down to the salesman; sometimes the owner himself is responsible.

Straight Rating Adopted as a Remedy

To prevent misapplications insofar as our salesmen are concerned, our company definitely adopted the straight-rating policy last January. Under this policy, a chassis is designed for a certain maximum load and our sales organization throughout the United States religiously adheres to the chassis gross rating. The results have been so satisfactory that there is no likelihood of our ever departing from this policy, as it thoroughly clears the picture insofar as misunderstandings with the owners about pay-load capacity are concerned.

Vehicles are properly tired, the gross-weight rating is established accordingly, and, as to the tire manufacturer, the responsibility for any abuse through excessive overloading beyond the specified and published recommended gross maximum vehicle-weight falls on the shoulders of the buyer. The time when the tire manufacturer is burdened with demands for unreasonable claims and adjustments will gradually become a thing of the past, provided the truck is sold right with tires of adequate carrying capacity, for many of the requests for adjustments received by the tire manufacturers in the past originated from the original factory tire-equipment being undersize for the gross weight of the truck. The best thing the motor-truck manufacturer can do is to provide vehicles with sufficient tire capacity, proper load distribution and a recommended maximum gross-weight rating.

The time has also passed by when the buyer will accept the statement of a truck salesman that his truck will carry 50 to 75 or even 100-per cent in excess of the manufacturer's rating. Several questions have been asked in some of the S.A.E. sessions regarding the straight rating. This is based on the maximum carrying capacity of the chassis and the tire-equipment capacity. For instance, a chassis having a nominal capacity-rating of 1½ tons may be rated up to a maximum gross weight of 8500 lb. One operator would put on this chassis a light platform-body weighing 800 lb., and another operator would use a 3000-lb. body. Where does the overload factor the salesman talked about come in when the 3000-lb. body is mounted on that chassis?

The truck manufacturer builds this chassis for a maximum gross weight of 8500 lb., that is, the combined weight of chassis, body, and pay-load. A printed warranty card is issued with each chassis, definitely stating the maximum gross weight allowed for the chassis and the recommended gross weight for the tire equipment. The gross figures for a certain size tire may be less than the figure indicating the maximum carrying capacity of the chassis. The maximum gross capacity of the chassis itself is not reduced when smaller size tires are specified, but, when tires with 6000-lb. capacity are used on a

[3] M.S.A.E.—Sales engineer, General Motors Truck Co., Pontiac, Mich.

chassis rated at 8500 lb., the recommended gross weight for that vehicle is only 6000 lb.

The support received from truck users has been very gratifying and I feel that it is only a question of time when other manufacturers will feel the same way about the straight rating as we do.

Load Distribution and Standardization of Body Load-Spaces Recommended

Next to the straight rating of the carrying capacity, proper load distribution is also of great importance to obtain economical operation.

It is a well-known fact that the front axle of a motor-truck has not the same carrying capacity as the rear axle. Also, very few front axles used today in motor-trucks support more than 33½ per cent of the total gross weight; most of them have less capacity. Load ratios that have been regarded as practical in the past range anywhere from 20 per cent for the front wheels and 80 per cent for the rear wheels, up to 25-75, 30-70 and, as the maximum, 33 1-3 to 66 2-3 for the gross-weight percentages between front and rear axles.

Three dimensions are involved in figuring percentage of load distribution: (*a*) wheelbase; (*b*) distance from the back of the cab to the center line of the rear axle, and (*c*) location of the center line of the load.

Standardization of wheelbase dimensions is impossible and it is not practical to set up any standard for locating the center line of the load, as this varies with the different body lengths suitable for the same chassis.

J. F. WINCHESTER

Industry Unsettled on Body Lengths

We made a search and a study of load-space dimensions and found that attempts had been made by the Society to standardize the length of motor-truck bodies. No results have been obtained in the past in standardizing any of the important dimensions of motor-trucks, and today the entire industry is floundering insofar as body load-space dimensions are concerned. The most important dimension in a truck chassis is the distance from the back of the cab to the center line of the rear axle. In our research work we found one prominent make with only 8 different load-space dimensions from the cab to the center line of the rear axle, while other companies ranged all the way up to 28 different dimensions for that distance.

One of the first consequences is danger of improper load distribution, when a standard stock-length body is mounted on a chassis. Another bad feature is that bodies are not interchangeable on chassis of different makes. Many motor-truck bodies are built to last 8 or 10 years, and it is not unusual for an operator to remove a body from an old truck and install it on a new chassis, but in doing so he is likely to find that the wheelhousing does not fall into the right place. Sometimes the truck manufacturer makes a change in the wheelbase dimension of a chassis, thus changing the dimension from the cab to the rear axle. We checked the requirements in body load-space dimensions of the various vocations and industries for three months. The study ranged from department-store delivery bodies to bakery and dairy bodies, dump bodies, oil tanks, and so on, every factor being taken into consideration. The solution we arrived at was such a simple one that everybody wondered why it had not been done before.

Eight Body-Length Standards Adopted

The following are considered suitable body-length standards and load-space dimensions from cab to center line of rear axle:

Standard Body Lengths, ft.	6	7½	9	10½	12	15	18	21
Standardized Load-Space, Cab to Center Line of Rear Axle, in.	39	48	59	70	82	99	115	135

You might ask, "What are you going to do when a man wants an 11 or 13-ft. body?" These load-space dimensions between the cab and center line of the rear axle permit a choice of additional optional body-lengths for each of these standards without resulting in any abnormal load-distribution. For light materials, the maximum allowable body-length fits the same load space between the cab and the rear axle, and for heavier materials shorter optional lengths can be mounted. Twenty-four different body-lengths can be mounted on only 8 standardized load spaces, and every body length conforms to common practice in the percentage of load distribution. In most cases, the standard body-lengths have 55 per cent of the body load-space ahead of the rear axle. That checks up favorably with the practice of 25-per cent gross weight on the front axle and 75 per cent on the rear axle.

Considering that some of the manufacturers, as in one instance mentioned, have up to 28 different load-space lengths from the cab to the center line of the rear axle, is it not time for the Society to do something toward standardizing the length of motor-truck bodies?

This is a very serious problem today. We cannot hope to standardize the wide variations in body design in the various sections of the Country but, as C. M. Eason stated in his talk in St. Louis last summer, the railroads have succeeded in building a standard box-car that is as suitable in the State of New York as in California for carrying various kinds of merchandise; but when it comes to motor-truck bodies, platform-stake bodies for instance, a Chicago type cannot be used on the Pacific Coast or in Kansas City or St. Louis for carrying the same kind of merchandise, and when a platform-stake body is built for New York City we have to put a hump in it sloping down to the rear, as New York operators say that they cannot use a level platform body. No standardization in styles is possible, but there certainly is room for greater uniformity in dimensions of the chassis for mounting the bodies.

I feel that the time has come for the Standards Committee of the Society to make a thorough study of the dimensional requirements for commercial bodies. Today we find bodies of all lengths, widths, heights and wheelhousing location. There is no reason why the motor-truck industry cannot compare notes and reach an agreement on the standardization of the one important dimen-

sion, the distance from the cab to the center line of the rear axle.

Truck Industry Should Study the Subject

C. F. CLARKSON[5]:—Mr. Schon has certainly stated the case forcefully, and I know that he has been studying the subject intensively for some time. It is a complex question. The S.A.E. committees have seen for years, at least in a dim way, that something should be done. From time to time we have set up standards that have proved to be paper standards and have not been effective. The whole matter of having an industrial standard obviously depends on what industry will do. It is a matter of business policy and expediency, and so forth.

Mr. Schon told about a straight-rating. I think that the whole matter has been clarified to a large extent by Mr. Schon, and that we should have more of the same sort of talk. We shall eventually have to come to the facts. Frequently, unfortunately, as an industry we have continually more or less ignored the facts that indicate what ought to be done. I think it is purely a matter of what the industry will support as a standard; it is for the industry to join in and continue the study, as started by Mr. Schon and his associates, and to see what can be done. It is absolutely clear, it seems to me, that something should be done to simplify this matter of truck-body construction and use which will, in any event, be complicated enough to be troublesome.

[5] M.S.A.E.—Secretary and general manager, Society of Automotive Engineers, Inc., New York City.

MR. WINCHESTER:—I have been much interested in Mr. Schon's and Mr. Clarkson's remarks and am certain that, if Mr. Schon would get the manufacturers who are represented in the National Automobile Chamber of Commerce to agree that the fundamentals are as simple as he has stated, there would be no difficulty at all in the S.A.E. establishing a standard of this kind. The Society has done considerable work and considerable progress has been made, but if we are to make a good showing in the future it will be necessary to have all interests represented and working together.

With the operators taking a greater interest in S.A.E. matters and the recognition of them as a part of the Society and its activities through Constitutional changes, the contact through the Society between them and the manufacturer should be more intimate in the future than it has been in the past, which would result in important discussions that will reconcile difficulties which may have existed.

With these contacts, the time is ripe for something to be done on the subject. It is a very important one and I hope that Mr. Clarkson and Mr. Schon will do everything they can in the next year or so toward accomplishing the type of standardization that has been discussed this afternoon. I am certain that, if the operators are convinced that the idea is right and will work conscientiously on this subject by specifying equipment according to these standards, it will be but a short time before the difficulties that are being discussed will be ironed out and greater transmission economies effected.

Body Design and Construction in Europe

(*Concluded from p.* 364)

tion of the cowl construction, especially in the framing and the way in which the windshield pillars are formed.

Can you give approximate figures as to the cost of your construction compared with the composite construction ordinarily used in this Country?

MR. HIBBARD:—The construction of the cowl is the same as with a wood frame except that metal castings are used instead of wood. Alpax castings are riveted to the front ends of the sills and are joined by another casting which forms the base of the windshield. The sheet metal of the cowl stops at the casting, and the cast aluminum-alloy windshield-pillars are bolted to it.

I cannot compare the cost with the cost of bodies made by American methods, but we find that the cost, in quantities as small as five, is a little less than that of our own composite bodies. I see no reason why this construction is not adaptable to quantity production, with suitable tooling.

QUESTION:—Do you use any anti-squeak materials?

MR. HIBBARD:—We use paper between aluminum surfaces in some of the bolted joints. No play is allowed in the joints, and we have had no trouble.

Standardization Progress

Aluminum Specifications

Proposed Revision of Present Specifications and Report on Protective Coatings for Aluminum

THE Subdivision on Light Metals and Alloys has submitted to the Non-Ferrous Metals Division, through its Chairman, P. V. Faragher, a draft of the proposed revision of the present S.A.E. Specifications on Aluminum and Aluminum Alloys. The material under consideration contains, in addition to the revision of present chemical compositions, some new alloys not heretofore covered in S.A.E. Specifications.

Following the policy of including, as "General Information" in the HANDBOOK, data on various processes and materials of general interest, the Non-Ferrous Metals Division will also consider the report on protective coatings for aluminum, which was submitted by the Subdivision. Both the revised specifications of aluminum alloys and the information on aluminum coatings are published herewith.

Proposed Revision of S.A.E. Aluminum Specifications

SPECIFICATION No. 36

Composition, in Percentage

Copper	7.0—8.5
Silicon	1.0—1.5
Iron	0.8—1.4
Zinc	not over 0.2
Manganese	not over 0.3
Magnesium	not over trace
Other impurities	not over 0.3
Aluminum	Remainder

General Information:

Standard tensile test specimens cast in sand and tested without machining give tensile strengths in the range 19,000 to 24,000 lb. per sq. in. The elongation is usually from 1 to 3 per cent in 2 in., but because of the difficulty of measuring elongations in this range with accuracy it is customary to omit elongation requirements from specifications for this alloy.

This alloy was developed from alloy No. 30 and differs from it only in that iron and silicon are added in carefully controlled amounts instead of being allowed to vary at random in the range permitted by the limit on impurities. In this alloy, iron and silicon are definite alloying constituents and are added to improve the casting characteristics of the old aluminum-copper casting alloy. With this alloy, the tendency for cracks and shrinks is very greatly decreased. It has largely superseded No. 30, particularly for more difficult castings that require pouring temperatures higher than are usually used.

This is a light alloy having a specific gravity of about 2.83 and is commonly used where alloy No. 30 has previously been specified. A shrinkage of 0.156 (5/32) in. per ft. should be allowed in pattern design. This alloy and No. 33 are most commonly used for casting crankcases, oil pans, differential carriers, transmission cases and other such castings.

SPECIFICATION No. 30

In the note to this alloy, add the following:

For more difficult castings, alloy No. 36, which has similar mechanical properties and superior casting characteristics, is now commonly specified.

SPECIFICATION No. 31A

Composition, in Percentage

Copper	2.0 — 3.5
Zinc	9.0 —11.5
Iron	1.25— 1.75
Total Other Impurities	not over 1.0
Aluminum	Remainder

Test specimens cast in sand and tested without machining give tensile strengths in the range 25,000 to 36,000 lb. per sq. in. and elongations from 3 to 7 per cent in 2 in.

The specific gravity is about 3.0. A shrinkage of 0.156 (5/32) in. per ft. should be allowed in pattern designs.

This alloy is used where somewhat higher mechanical properties are desired than are obtained with alloys No. 30, 33 and 36. In common with other alloys containing considerable percentages of zinc, this alloy loses its strength more rapidly as the temperature is raised than do some of the other alloys, hence it is not recommended for use at elevated temperatures.

SPECIFICATION No. 37

Composition in Percentage

Silicon	12.0—13.0
Iron	not over 0.8
Copper	not over 0.3
Zinc	not over 0.2
Manganese	not over 0.5
Magnesium	not over trace
Total Other Impurities	not over 0.3
Aluminum	Remainder

General Information:

Standard test bars, cast to size in sand, show tensile strengths from 24,000 to 31,000 lb. per sq. in. and elongations from 5.0 to 15.0 per cent. These properties are obtained only if the molten alloy is subjected to a special process, known as "modification," immediately before it is poured. The specific gravity is 2.68.

Like alloy No. 35, this alloy is especially resistant to salt-water corrosion. Because of its good foundry characteristics it can be used for complicated castings consisting of both thin and heavy sections. The ratio of yield-point to ultimate tensile-strength is somewhat lower than is the case with some of the other aluminum casting-alloys, which fact should be considered in connection with the properties shown in the preceding paragraph.

SPECIFICATION No. 38 (HEAT-TREATED CASTINGS)

Composition, in Percentage

Copper	4.0—5.0
Silicon	not over 1.20
Iron	not over 1.20
Zinc	not over 0.25
Total of all constituents except aluminum and copper	not over 2.5

General Information:

Castings from this alloy can be heat-treated to produce mechanical properties distinctly higher than those of the ordinary aluminum casting-alloys. The heat-treatment may be varied depending upon the service requirements.

Where maximum toughness and resistance to shock are desired, a solution heat-treatment alone is used, which produces in sand-cast test-specimens tensile strengths from 28,000 to 38,000 lb. per sq. in. and elongations from 6 to 12 per cent in 2 in. On standing at room temperatures, there is an aging effect which is practically complete in a few months. The tensile strength increases by a few thousand pounds per square inch, and the elongation decreases by a few per cent in 2 in. The greatest change occurs in the yield-point, which increases to a value usually well in excess of 20,000 lb. per sq. in.

If somewhat greater initial strength, hardness, and yield-point are desired, the solution heat-treatment may be followed by a precipitation heat-treatment in which tensile strengths from 30,000 to 40,000 lb. per sq. in. and elongations from 3 to 8 per cent in 2 in. are developed.

If still greater strength and hardness are desired, the heat-treatment may be

varied to produce tensile strengths from 36,000 to 50,000 lb. per sq. in. and elongations from 0 to 5 per cent in 2 in.

Since the introduction of this alloy, its use has developed into very substantial tonnages. It is used in windshield frames, fire-engine, motorcoach-engine and aircraft-engine crankcases, and for a variety of parts in both motor-vehicle and aircraft assemblies, where a high-strength light-weight casting is desired. It is very much more resistant to corrosion than the ordinary alloys containing copper and is extensively used in the manufacture of outboard motors and for castings to be used on board ships.

SPECIFICATION No. 39

Composition, in Percentage

Copper	3.75—4.25
Nickel	1.8 —2.3
Magnesium	1.2 —1.7
Iron	not over 1.0
Silicon	not over 0.7
Total other impurities	not over 0.2
Aluminum	Remainder

General Information:

Standard test-specimens, cast to size in sand, after proper heat-treatment show tensile strengths from 30,000 to 42,000 lb. per sq. in. and elongations from 0 to 2.0 per cent. If the alloy is not heat-treated, the tensile strength is about one-third less than these values. Because of its property of retaining its strength better at elevated temperatures than do many of the other aluminum alloys, it is used for pistons and cylinder-heads of aircraft engines and for other parts where this property is an advantage.

ALLOY No. (blank)

Composition, in Percentage

Copper	3.5—4.5
Magnesium	0.2—0.75
Manganese	0.4—1.0
Aluminum	not less than 92.0

General Information:

This alloy is the alloy commonly designated "duralumin," "Dural" or "17S." It is used in the wrought condition either rolled, drawn-forged or extruded. In the form of sheet, this alloy is supplied to the following mechanical property requirements:

DURALUMIN OR 17S SHEET, HEAT-TREATED

Thickness, In.	Minimum Tensile Strength Lb. per Sq. In.	Minimum Yield-Point, Lb. per Sq. In.	Minimum Elongation in 2 In., Per Cent
0.010 to 0.020	55,000	30,000	15
0.021 to 0.128	55,000	30,000	18[a]
0.129 to 0.258	55,000	30,000	15
0.259 to 0.500	55,000	30,000	12
0.501 to 1.75	55,000	30,000	9

[a] Sheets 30 in. or more in width in thicknesses of 0.021 to 0.040 in. may show a minimum elongation of 17 per cent.

In the annealed temper, the tensile strength shall not exceed 35,000 lb. per sq. in.

The following thickness tolerances are commercial for this product:

THICKNESS TOLERANCES FOR DURALUMIN OR 17S SHEET

	Plus or Minus Tolerance, in Inches—Widths—		
Thickness, In.	18 In. and Less	Over 18 In. to 36 In.	Over 36 In.
0.013 to 0.036	0.0015	0.002	0.0025
0.037 to 0.050	0.002	0.0025	0.003
0.051 to 0.070	0.0025	0.003	0.004
0.071 to 0.090	0.003	0.003	0.004
0.092 and heavier	5% T	5% T	....

(T = nominal thickness of sheet.)

In the form of tubing and extruded shapes, the same tensile strength and yield-point are obtained, the elongation varying with the cross-sectional area of the test section. Rod and bar will also show these same properties, except in certain of the larger sizes where manufacturing limitations may result in slightly lower values.

This alloy is extensively used in the construction of motorcoaches, trucks, and aircraft, both heavier and lighter than air. It is available in all the forms in which metals are commonly used: sheet, plate, strip, tubing (including streamline and other special shapes), bar, rod, wire, rivets, bolts, nuts, screws and other screw-machine products, structural shapes and extruded sections specially designed for aircraft construction.

ALLOY No. (blank)

Composition Limits, in Percentage

Copper	3.9—5.0
Manganese	0.5—1.1
Silicon	0.5—1.1
Aluminum	not less than 92.0

General Information:

This alloy is known as 25S and, like duralumin, is used in the wrought condition. In the fully heat-treated temper, the tensile strength is from 55,000 to 63,000 lb. per sq. in. The elongation, except for very thin or very heavy sections, is between 16 and 22 per cent in 2 in. If the alloy be given the solution heat-treatment, but not the precipitation heat-treatment, it is in a more workable condition and has the following properties:

Tensile Strength, 45,000 to 53,000 lb. per sq. in.

Elongation, 15 to 22 per cent in 2 in.

Yield-Point, 15,000 to 30,000 lb. per sq. in.

In the annealed temper, the tensile strength varies from 25,000 to 35,000 lb. per sq. in.

This alloy is commonly available in a variety of forms including sheet, plate, bar and structural shapes. It is especially adapted for the manufacture of forgings, because of its excellent hot-working properties. Forgings of this alloy in common use include connecting-rods for automobile engines, propellers for aircraft, automobile hardware and fittings of various types.

ALLOY No. (blank)

Composition Limits, in Percentage

Magnesium	0.45—0.9
Silicon	0.6 —1.2
Aluminum	not less than 96.3

General Information:

This alloy is designated in the trade as 51S. It is used in the wrought form and is one of the alloys susceptible to heat-treatment. In the fully heat-treated temper (designated T), the tensile strength is from 45,000 to 50,000 lb. per sq. in.; the elongation varies from 10 to 18 per cent in 2 in. except in very thin or very heavy sections. The yield-point is from 30,000 to 40,000 lb. per sq. in.; substantially the same as that of duralumin or 25S, although the ultimate strength is about 10,000 lb. lower than that of these alloys. If the alloy is not subjected to the precipitation heat-treatment after it has been heated and quenched, it has a tensile strength in the range 30,000 to 40,000 lb. per sq. in. and an elongation of 20 to 30 per cent in 2 in. In this temper (designated W) the alloy can be formed with considerable ease. In the annealed temper, the tensile strength varies from 14,000 to 19,000 lb. per sq. in. and the elongation from 22 to 32 per cent in 2 in.

This alloy is available in practically all the wrought forms in which aluminum and other metals are produced; these include sheet, plate, tubing, rod, bar, wire, shapes, moldings, both rolled and extruded, forgings, and so forth.

Because of the readiness with which this alloy can be worked hot, it is used for the manufacture of complicated forgings, such as radial aircraft-engine crankcases. It is also used for less highly stressed parts, such as automobile hardware.

ALLOY No. (blank)

Composition Limits, in Percentage

Manganese	1.0—1.5
Copper	not over 0.2
Aluminum, minimum	97.0

General Information:

This alloy is used to replace pure aluminum where somewhat higher tensile strength and hardness are desired. It is not quite so easily formed as is commercial aluminum in the corresponding tempers. This alloy shows substantially the same resistance to atmospheric corrosion and to most forms of chemical attack as does aluminum of commercial purity.

As is the case with commercial aluminum, the various tempers are obtained by varying the amount of cold work done on the alloy after its final annealing. It is regularly manufactured in the form of sheet, plate, tubing, rod, bar and wire, extruded shapes, moldings, and so on.

The alloy in the various standard tempers has the tensile strengths shown in the following table. The elongation values for flat sheet are also shown. In the case of strip sheet in the half-hard temper, the elongation may be slightly lower than the values shown for flat sheet.

Temper	Tensile Strength, Minimum, Lb. per Sq. In.	Elongation, Per Cent in 2 In. Thickness, In.						
		0.013 to 0.019	0.020 to 0.031	0.032 to 0.050	0.051 to 0.113	0.114 to 0.162	0.163 to 0.258	0.259 to 0.375
Soft	14,000	20	20	23	25	25	25	28
One-half Hard	19,500	3	4	5	6	7	8	8
Three-fourths Hard	24,000	1	2	3	4			
Hard	27,000	1	2	3	4			

The thickness tolerances in the following tables are met in commercial manufacture of sheet.

THICKNESS TOLERANCES FOR FLAT SHEET

B. & S. Gage	Thickness, In.	Width: 20 In. and Under	Width: Over 20 In. to 36 In. Incl.	Width: Over 36 In. to 60 In. Incl.
2 and 3	0.250[a]— 0.220	±0.007	±0.008	±0.009
4 to 9	0.219 — 0.115	±0.005	±0.006	±0.007
10 to 13	0.114 — 0.073	±0.003	±0.0035	±0.004
14 to 21	0.072 — 0.030	±0.0025	±0.0025	±0.003
22 to 24	0.029 — 0.019	±0.002	±0.002	±0.003
25 to 27	0.018 — 0.014	±0.002	±0.002	±0.002
28 to 36	0.013 — 0.005	±0.0015	±0.0015	±0.0015

[a] *Note:* Material having thickness greater than 0.250 in. is considered plate and is covered by plate tolerances.

THICKNESS TOLERANCES FOR STRIP SHEET

B. & S. Gage	Thickness, In.	Width: ¼ In. to 12 In., Incl.	Width: Over 12 In. to 24 In., Incl.
10 to 18	0.102—0.041	±0.003	±0.003
19 and 20	0.040—0.030	±0.002	±0.0025
21 to 25	0.029—0.017	±0.002	±0.0025
26 to 29	0.016—0.011	±0.0015	.....
30 to 36	0.010—0.005	±0.001	.....

SPECIFICATION No. 33

Composition, in Percentage	
Copper	6.0—8.0
Zinc	not over 2.5
Iron	not over 1.5
Silicon	not over 1.0
Total other impurities	not over 1.0
Aluminum	Remainder

Test specimens cast in sand and tested without machining show tensile strengths in the range 19,000 to 24,000 lb. per sq. in. and elongation from 1.0 to 2.5 per cent in 2 in. It is customary to omit elongation requirements from specifications for this alloy.

General Information:

This is a light alloy, having a specific gravity of 2.83 to 2.86, and has been the most extensively used alloy in the automotive industry. It is similar to Specifications Nos. 30 and 36 and is used for crankcases, oil pans, steering-wheel spiders, differential carriers, transmission cases, camshaft housings, hub caps and similar parts. A shrinkage of 0.156 (5/32) in. per foot should be allowed in pattern designs.

SPECIFICATIONS Nos. 30, 31, 32, 34

Omit aluminum minimum and the percentage designated in the composition limits for each of these alloys.

Add as the last item of each of the alloy compositions:

Aluminum	Remainder

With the exception of this change, retain the specifications as printed in the present HANDBOOK.

SPECIFICATION No. 35

Change composition to the following:	
Silicon	4.5—6.0
Copper	not over 0.6
Iron	not over 1.0
Zinc	not over 0.2
Manganese	not over 0.3
Magnesium	not over trace
Other impurities	not over 0.3
Aluminum	Remainder

SPECIFICATION No. 78

Change the title of the table of physical properties at the top of p. 505 to read: Physical Properties of Aluminum Flat Sheet.

Add the following paragraph immediately following this table:

Aluminum strip sheet shows the same physical properties as flat sheet, with the exception that in tempers No. 4 and No. 6 the elongations may be slightly lower than those shown for flat sheet.

Replace the table of thickness tolerances with the same tables as given in this memorandum for aluminum-manganese alloy sheet and strip.

Protective Coatings for Aluminum

ALCLAD ALLOYS

Aluminum is highly resistant to atmospheric corrosion and to a variety of chemicals. In general, the resistance is greater, the higher the purity of the metal. The improvement in mechanical properties which results from the alloying of the metal is usually attended by some loss in corrosion resistance. This effect varies with the constituent which is added, and also in some cases with the heat-treatment which the alloy receives.

Aluminum of commercial purity contains a minimum of 99 per cent of that metal, the impurities consisting principally of iron and silicon. This metal is somewhat less resistant to severe corrosive conditions than is high-purity aluminum.

For ordinary atmospheric conditions, commercial aluminum and practically all of its commercial alloys show very satisfactory resistance to corrosion. The alloy containing 1¼ per cent of manganese (Specification No. ——) is at least the equal of commercial aluminum in this respect.

Of the casting alloys, those containing silicon as the hardening element (Specifications Nos. 35 and 37) are the most resistant to salt water. The heat-treated copper alloy (Specification No. 38) follows these very closely and is distinctly superior to the other alloys containing copper (Specifications Nos. 30, 32 and 33). The alloy containing considerable percentage of zinc (Specification No. 31) is the most susceptible to the action of salt water of any of the casting alloys in common use.

The strong wrought alloys (Specification Nos. —— and ——) are not so resistant to highly corrosive conditions as are pure aluminum and the wrought alloy containing manganese.

There are also appreciable differences in this property among the different alloys and in the various tempers. In every case the alloy is in its most resistant state when it has been subjected to the solution heat-treatment alone and has not been subsequently heated to bring about the precipitation heat-treatment or artificial aging.

The most resistant of all of these materials is the alloy containing magnesium and silicon (Specification No. ——) when in the intermediate temper (W). This advantage is lost, however, when it is artificially aged to develop its maximum properties (T).

The alloy containing copper and

magnesium, and manganese, commonly known as duralumin or 17S, is the only one of these alloys which develops its maximum properties on aging at room temperature after the solution heat-treatment. In line with the statement previously made, it is the most resistant to corrosion of any of the aluminum alloys when in their strongest temper.

The choice among these alloys will depend largely upon the nature of the service they are to perform and upon the design of the part.

For comparatively thin, highly stressed sections, such as wing ribs and tubular struts used on aircraft, duralumin or 17S or Alclad 17S is always to be chosen. For heavier sections such as engine crankcases, where superficial surface action would be of little consequence even if it should occur, the other alloys (Specifications Nos. —— and ——) are regularly used with entire satisfaction. Similarly, plates and structural shapes used in motorcoach and motor-truck body construction may be made from any of the three alloys.

Even though these alloys are quite resistant to ordinary atmospheric conditions, it is recommended that a protective coating be applied as an added precaution. Aluminum paint made by adding aluminum-bronze powder to a suitable grade of long oil varnish is commonly used. Where the part is in contact with water, bituminous paints may be used. Good results have been obtained on seaplane floats using a zinc-chromate paint and also with red-oxide paint, although comparative corrosion tests indicate that the aluminum paint affords better protection against salt-water corrosion.

It should be emphasized that the preparation of the surface of the metal is as important as the selection of the paint to be used. Work is still in progress by the manufacturers of these alloys and by Government bureaus to determine the best methods of protection.

Up to the present, no method has been devised which gives better results than the anodic oxidation of the surface prior to the application of the paint. This process consists of making the alloy anode in a solution of chromic acid under proper conditions of voltage, temperature and time.

For other less exacting conditions of service than seaplane work, other methods of securing paint adherence may be adequate. The work now in progress may develop methods which are equally effective and at the same time more easily applied.

Taking advantage of the superior corrosion resistance of aluminum of high purity, a process has been developed for manufacturing sheets having a core of 17S (Specification No. ——) with surface layers of pure aluminum alloyed and integral with it. This product is marketed under the trade mark Alclad 17S.

Tensile-test specimens of this material exposed for more than 18 months to a standard salt-spray test have shown no loss in tensile strength or elongation. The pure metal not only protects the alloy where it covers it but also protects sheared edges or scratches through the surface layers by its electrolytic action. It has also been found that ordinary duralumin or 17S rivets receive a very considerable amount of protection from contact with the pure-aluminum surface when used with Alclad sheet.

When this material is used for seaplane construction, it is advised that the sheet be given the same measure of surface protection that is given to the ordinary alloy. Service tests may show this not to be essential, but it is considered desirable added insurance of satisfactory performance under such adverse conditions. For the less exacting service of landplanes, Alclad sheet is in use without the protection of a paint coating and is showing entirely satisfactory results.

Meetings of Aircraft Divisions

St. Louis Aeronautic Meeting Affords Opportunity for Standards Committee Conferences

ADVANTAGE was taken of the presence of numerous members of the Aircraft-Engine Division and the Aircraft Division of the Standards Committee at the Aeronautic Meeting of the Society held in St. Louis, Feb. 18 to 20, inclusive, to convene Committee meetings. A brief account of the proceedings is appended.

Aircraft-Division Proceedings

The primary purpose of the meeting of the Aircraft Division was to inaugurate a program of standards activity for this Division, since no continuing projects were available. A predetermined list of possible activities, gathered from various sources within the membership, was discussed item by item. Consideration of these items was undertaken from the vewpoint of (*a*) whether their standardization is desirable; (*b*) whether it is practicable at this time; (*c*) the extent to which the activity should be developed if found advisable; (*d*) bringing out such details of particular intimate company experience of those present as to significant factors to be considered in such standardization; and (*e*) calling to attention sources of interesting detailed information to be considered in formulating a standard. Correspondence from Division members offering comment on the proposed activity was read and considered in formulating action.

While the result has left the Division with a considerable program of activity, which will be referred to subdivisions for detailed investigation and development, the membership of the Society is urged, through an invitation to be extended by those present, to bring to the attention of the Chairman or any member of the Division any subject that may be possible of standardization which occurs within their experience. Only by such cooperation can this Committee render a full measure of service to the aeronautical industry and the membership of the Society. It is hoped that action in the present program can be expedited so that detailed recommendations can be evolved in the subcommittees for consideration at the Aeronautic Meeting to be held in Detroit in April.

J. F. HARDECKER

Chairman of the Aircraft Division of the Standards Committee of the Society

Subjects for Subdivision Action

The subjects which will be referred to subdivisions for detailed action are:

(1) Streamlined tubing shapes (steel and aluminum alloy)

(2) Aircraft-tubing sizes (round and streamlined—steel and aluminum alloy)

(3) Shock-absorber struts (and connections)

(4) Flat-head pins
(5) Extruded aluminum-alloy structural shapes
(6) Streamlined and internal tie-rods
(7) Countersunk - head aluminum - alloy rivets
(8) Aircraft pulleys (spacers for and ball-bearing type)
(9) Fire-extinguisher mountings
(10) Ball hexagonal bolts and nuts (elimination as standard)

Aircraft-Engine Division Action

At the meeting of the Aircraft-Engine Division of the Standards Committee held Feb. 19, dimensions for the No. 50 splined shaft-end were approved, subject, as usual, to letter-ballot confirmation of the entire Division. Some of the dimensions on the original proposal were changed to conform to present shafts as manufactured for use in the Hornet and the Cyclone engines. With these revisions, the proposal will be submitted to the Standards Committee for approval as an addition to the present standard series of splined shaft-ends.

The Division also requested that an error in the present *F* dimension for the No. 20 splined shaft-end, as shown in the S.A.E. HANDBOOK, be corrected in the 1930 edition. This being only a typographical error in setting the original specification, no formal action of the Division is necessary, and the correction will be made to show dimension *F* as 6¼ instead of 6⅜ in., which is the dimension to which all the No. 20 shafts so far manufactured have been made.

Although engine shaft-ends have been standardized for some time, no previous attempt has been made to standardize propeller-hub cones and nuts. A tentative specification was recently sent to members of the Division for comment and was submitted at this meeting for consideration. The specifications as originally submitted were printed in the Standardization Progress department in the January, 1930, issue of the S.A.E. JOURNAL, beginning on p. 100. In considering them finally, it was necessary for the Division to change the cone dimensions of the No. 50 cone to conform to the revised dimension on the No. 50 shaft-end as approved. With such changes, the Division approved as an S.A.E. Standard the cone and nut dimensions for the Nos. 10, 20, 30, 40 and 50 splined shaft-end to be submitted to the rest of the Division members by letter-ballot and subsequently to the Standards Committee in May, 1930, if approved by this Division's letter-ballot.

The proposed No. 0 tapered shaft-end, approved by a letter-ballot of the Division in the Fall of 1929, was further discussed before presenting it to the Standards Committee, and it was decided that a survey of the engine manufacturers who use such a shaft-end should be made before any further action is taken. In this connection Mr. Caldwell, of the Hamilton Standard Propeller Co., will be requested to submit a list of the companies to which hubs are supplied for this shaft-end.

Further work was done on the wood-propeller hub standardization, but no conclusions were reached owing to the absence of accurate data. Arthur Nutt, Chairman of the Division, will ascertain the ideas of the various members of the Division as to the dimensions that should be considered in such a specification and what the dimensions should be.

Several Subjects Tabled

It was definitely decided that tank outlets are not a subject for standardization by the Aircraft-Engine Division and that, at present, it is not necessary to do anything with this item; likewise, that it is too early to take any definite steps looking toward the drafting of specifications for shielded spark-plugs. The question of standardizing engine-mounting dimensions was again brought up but was definitely tabled because mounting dimensions are not a feature of engine construction which lends itself in any way to standardization, on account of its interference with design.

Guides in Standardization

DEFINITE progress in the automobile industry in France toward the adoption of standards centers in the Bureau de Normalization de L'Automobile in much the same way that this work has been carried on in America by the Society. A loose-leaf HANDBOOK of the standards established is issued and a number of the standards that have been adopted follow very closely those of the S.A.E., inch dimensions being translated into the equivalent metric dimensions. M. P. Berger, a member of the Society and engineering director of the Bureau, which is located in Paris, maintains contact with the Society in this work, and interesting letters are frequently received from him. A recent letter includes the following interesting rules to govern the general principles of standardization:

(1) Observe good constructional principles, establishing always the perfection of the standardized article.

(2) Reduce the number of dimensions to a reasonable minimum and make them conform so far as possible to a standard series of geometric progression to which the parts are scaled approximately.

(3) Provide for interchangeability so far as economy permits in the nature of the commodity.

(4) Choose dimensions, so far as possible, which are used in practice.

(5) Assure the practicability of the standard.

(6) Do not refuse to consider a project merely because a long time might elapse before a standard could be adopted in practice.

(7) Keep the future in mind in carrying on the work.

(8) Work independently of commercial organizations; standards are for the general good and not for the accommodation of only a few interests.

(9) Do not insist too strongly on standardization which has only economy and usefulness as its principal fundamentals. Standardization should not be pushed to a point which makes further improvement impossible. Do not reduce the number of models so much as to unnecessarily restrict the users of the article.

(10) Do not insist too strongly on one or two principles to the exclusion of others which are of equal importance.

Trend in American Standardization

The years of experience of the Society's Standards Committee has proved the wisdom of the policy that standardization follows established practice and that standards cannot establish practice. A standard is usually a compromise tempered by good engineering principles and economy in production, and must always be flexible enough to meet changing conditions over periods of time.

The American automobile industry has entered an era in which standards of major importance relate mainly to fundamentals of engineering designs or specifications for parts and materials that are used by virtually all industries and that are usually procurable on the open market. Production quantities in individual plants have become so large that the economies in procurement, manufacture, sale and use of the commodity warrant deviation from many of the more detailed and specialized standards that were of great value to the industry in the earlier days of its development when work was done on more limited scales.

Other great mechanical industries have taken up standardization within their fields, and this growth necessitates National and, in many instances, international correlation of effort in the formulation of fundamental common standards. The evolution has been as pronounced in the field of standardization as it has in design, and it is only by proper organization, within individual companies, of engineers of the executive type who are trained in standards work that standards can be made what they ought to be and full value derived from their use.

Production Engineering

Recent Production Papers

Bibliography of Articles in THE JOURNAL *on Subjects of Interest to Production Men*

PRODUCTION papers and articles that had appeared in THE JOURNAL before that time were listed in the Production Engineering department in December, 1927, p. 639. Since then a considerable number of additional papers have been printed, and the list following is supplementary to the one previously given.

Groups of the papers by subject are continued as in the original list, no cross-indexing being provided.

The complete list will be prepared, under the direction of the Production Activity Committee of the Society, in the form of a pamphlet, a copy of which will be furnished gladly to any reader of the S.A.E. JOURNAL upon request, as soon as this pamphlet is available.

Factory Equipment

Conveyors

Selection of Speed Reducers for Conveyors; by C. E. Broome. S.A.E. JOURNAL, January, 1929, p. 57.

Cutting-Oils

Cutting-Oils; by J. C. Sharp. (Soluble oils Economical if cooling is chief function.) S.A.E. JOURNAL, January, 1929, p. 90.

Machine-Tools, Tools and Fixtures

Tool Standardization. S.A.E. JOURNAL, June, 1928, p. 691.

Metal-Cutting with Diamonds. S.A.E. JOURNAL, October, 1928, p. 419.

Tungsten-Carbide Tools. (Descriptive bibliography of trade-paper articles and data from S.A.E. meetings.) S.A.E. JOURNAL, September, 1929, p. 307.

A Production Machine-Tool of Elastic Design; by J. B. Armitage. (Describes a milling-machine having standard heads and components that can be arranged in a variety of ways for specific operations.) S.A.E. JOURNAL, January, 1930, p. 87.

Demands of Machine-Tools; by W. P. Michell. (Requirements and experiences recounted by engineer of a large maker of commercial vehicles and discussed by others.) S.A.E. JOURNAL, January, 1930, p. 103.

Miscellaneous Equipment

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Transportation Engineering

Motor Transport's Broad Field

Operating Specialization Can Well Be Intensified in Fleet-Supervisors' Realm

THE vocation of the highway-transportation engineer has not yet reached the stage of specialization, according to F. J. Brackett, of the transport survey department of the General Motors Truck Co., whose paper on Highway-Transportation Engineering was scheduled for presentation as an Engineers Club paper at a recent joint meeting of the Engineers Club of Philadelphia and the Pennsylvania Section of the Society.

Mr. Brackett's paper, in part, states also that, in the beginning of the use of the commercial motor-vehicle, no transportation-engineering service was necessary or desired, but that it is now possible to determine with reasonable accuracy the probable result of the ordinary proposed venture in commercial-vehicle transportation. Vehicle costs are quite definitely known, the commodities that can be profitably handled are being indexed, and bitter experience has developed the general rate-level necessary for profitable operation. It may be added that this rate-level is being constantly lowered. Human nature and its reactions are the most serious unknown elements, although this but adds a desirable spice and spur to the adventure.

Motor Transport Status Outlined

Transportation by motor-vehicle differs very materially from that furnished by the older forms of common carrier; in both passenger and freight divisions, it approaches a door-to-door service; the most favorable mileage profits in no way approach those of the older agencies; and losses on any class of business cannot be absorbed, since the profit on the best is small, according to Mr. Brackett. Costs of any division of the business are readily obtainable, detailed revenues are easily ascertained, and daily gross and net-revenue reports can be made available within 24 hr. of the actual performance. General overhead and undistributable costs are small, and any change in the volume of service offered is immediately reflected in the costs. The necessary records are simple and few. The officers usually have ample authority to decide all questions promptly, because the ever-changing nature of the business indispensably requires this.

Perhaps no industry ever had a more rapid growth; its future growth may exceed even past records. Freight transportation by motor-vehicle is now largely in the hands of a myriad of small operators. Central freight-stations, interchange of traffic between the numerous lines, definite schedules and rates still are the exception, but this condition is rapdily changing. The requiring of certificates of convenience and necessity, the economy of tractor-trailer operation with its probable greater investment-demands, and the realized necessity of having some convenient terminus at which the public can receive and forward freight, are making the business less attractive to the small individual, asserts the author, and much more so to those having greater financial means.

A few States now have fairly comprehensive regulatory systems that offer a certain amount of protection against irresponsible competition. Common-carrier trucking is advancing rapidly in such States. Numerous localities now exist in which the organized freight-truckers handle a greater tonnage than the largest of the railroads operating there. Coal is being transported from mine mouth direct to consumer; fresh meat is carried by motor-truck in carload quantity to distances of 200 miles. One packing-house, killing 400 animals daily, has received all of its live animals by truck during the last year and has forwarded by the same form of transport almost all of its finished products.

There seems to be almost no limit to the distances over which household goods and other similar articles can be economically transported by truck. This, of course, is because the use of the truck avoids expensive crating and high charges for hauling from a freight terminal to the house. Nearly all of Cincinnati's milk reaches the city by motor-truck, and the proportion in Detroit is even higher. Much of the milk moves in glass-lined tanks mounted on trucks and trailers; three or four tanks form the usual load for one power-unit.

In one Texas county last year, most of the cotton crop moved to the gin and thence to the shipside by truck; two years previously, all was carried by the railroads. Peaches and strawberries reach the large eastern markets largely by truck, the journey being usually completed between mid-afternoon and the opening of the morning markets. Long Island ducks ride in nothing but specially constructed limousines. Frequently the truckman serves also as the agent of the shipper in the disposition of the cargo.

Reasons for Shipping by Truck

In all cases a very plain reason exists for this use of the truck. Coal is stored at the mine pending delivery orders for a definite cellar, rehandling and overhead charges at the dealer's yard are eliminated, and the dealer still functions but devotes his entire energy to selling. Under this plan, coal is being moved distances up to 50 miles. At one point in Illinois an average of 1700 tons per day is so handled, and at considerably less cost than the former charges for transportation, storage, handling and delivery.

Railroads necessarily require that freight be shipped in quantity if charged for at carload rates. The trucker, using smaller-capacity vehicles, exacts a much smaller minimum weight. In addition, he has found that the delivery of parts of a full truckload to several adjacent destinations involves very little added expense. In one western town are four meat markets; formerly, each one received a carload of fresh meat by rail twice a week, but now the truckman brings each butcher 1 to 2 tons daily. Under the old plan they were frequently sold out of certain articles and therefore lost much of the potential business. Under the new plan they are able to inventory the supplies at 6 p. m., telephone an order to the packing-house, say 150 miles distant, and find the desired supplies in the cooler at opening time the next morning. Incidentally, the butchers say that the entire cost from packing-house to cooler is about one-quarter less than by the former method. Were it a quarter higher, they would still use it.

Progress of Passenger Transport

Passenger transportation by motor-vehicle has made even greater progress, continues Mr. Brackett. In 1928, 2,500,000,000 passengers were carried by motorcoaches; in the same year, the steam railroads carried 799,000,000. It is now possible to travel by motor-coach from New York City to Los Angeles in 5½ days. One-seventh of all American cities having a popula-

tion between 10,000 and 100,000 are now served exclusively by motorcoaches; nearly double that number have a partial coach service. The number of towns served by motorcoaches only is growing rapidly. In western New York State, one motorcoach company has replaced six former electric-railway operations; all six were unprofitable, but the coach company paid 8 per cent dividends for several years.

At the beginning of 1928, the route mileage of common-carrier motorcoach operations was about four times the mileage of electric-railway track, or three-quarters of the track mileage of the steam railroads. At the end of 1928, common-carrier motorcoach route-mileage was more than seven times the mileage of electric-railway track, or more than one and one-quarter times the track mileage of the steam carriers.

From 1925 to 1929, the mileage of surfaced highways in the United States increased from 471,667 to 615,000. Present construction programs promise an even more rapid increase in the near future, and every mile of improved highway is a potential motorcoach and motor-truck route. In the four years preceding 1928, the number of motorcoaches operated in the United States increased from 53,000 to 86,000. Motorcoach operation is fast becoming a part of big business. At the beginning of 1929, 322 steam and electric railroads were operating 11,318 motorcoaches, and 45 companies operated 22.65 per cent of all the common-carrier motorcoaches of the United States.

Transport Engineer's Difficult Task

The highway-transportation engineer concerns himself with all of the various activities mentioned, although his vocation has not yet reached the stage of specialization. Financing, garage facilities, operating rules and practices, franchising, accounting and tax problems all come within his general realm. With the growing interest now being shown in motor-vehicle operations by investment and banking houses, a large additional field is opening, asserts Mr. Brackett. The engineer always has attempted to estimate future earnings of proposed operations, but the estimating of the results to be obtained by the consolidation and expansion of present operating companies will be an even more difficult task.

Papers in This Issue

IN THE paper by Albert Kahn, entitled Garage and Shop Design, which begins on p. 365, the author discusses multiple-story structures and specifies the requirements of the design, afterward going into detail concerning the planning of a motorcoach garage and particularizing on numerous details that tend toward ease of operation and economy in both housing and servicing the vehicles.

Commercial-vehicle bodies are divided into two general groups by John Walker, author of the paper on Modern Motor-Truck Bodies, which is printed in this issue beginning on p. 372. The standard bodies offered for sale complete as a unit with the chassis by the truck manufacturer constitute the first group, and custom-built bodies ordered separately by the purchasers of truck chassis are in the second group.

Excerpts from papers presented at the New England Section will be found on p. 399 of this issue. The titles are, Fundamental Economy of Automotive Service Labor, by L. T. Hanford; and Service Management, by Knox T. Brown.

Plan Now to Attend

the

S. A. E.

25th

Anniversary Celebration

1930 Summer Meeting

French Lick Springs, Ind.

May 25 to 29

St. Louis Aeronautic Meeting

(*Continued from p.* 311)

the vapor-locking temperature will be given by the so-called true vapor-pressure rather than by some other test.

T. B. Rendel, of the Shell Petroleum Corp., said, regarding experiences with fuels in actual carbureters, that he feels sure that Dr. Bridgeman will find diversity in his predicted results because some carbureters can handle more vapor than others. It must be remembered, he said, that in certain cases a carbureter may be set rich and therefore a slight decrease in the flow through the jet will not affect the engine performance, which is the only gage of practical gasoline value. Mr. Rendel's experience is that the 10-per cent point for vapor-pressure, or any other test that one might like to make in that connection, will give variable results unless the carbureter supply, the carbureter characteristics and design, and the other parts of the fuel system are taken into consideration.

E. B. Heath, of the Heath Aircraft Corp., related his experiences with regard to vapor lock and described briefly the means by which these difficulties were overcome.

In replying to the suggestion made by Chairman Peck that a closer understanding between the engine designer and the airplane designer in regard to the proper hook-up of the engine would be of great benefit in eliminating gas lock, Dr. Bridgeman agreed that closer cooperation is desirable, but said that the problem of vapor lock is not limited to any one industry or to any designer. He said further that the engine designer cannot blame the petroleum industry solely for vapor-lock troubles. Unquestionably, in his opinion, the procedure should be to obtain the best type of fuel for use in an optimum type or types of fuel system.

In the opinion of Dr. R. Haskell, of The Texas Co., aviation gasolines are the best stabilized of any. He mentioned that most gasolines contain certain amounts not only of propane but of other dissolved gases which are really gases and not liquids. These are dissolved in the gasoline and, when a distillation test is made, the gases are distilled off and do not return. In conclusion, consideration was given to vapor-lock as a possible cause of airplane crashes.

Society's Interests Promulgated

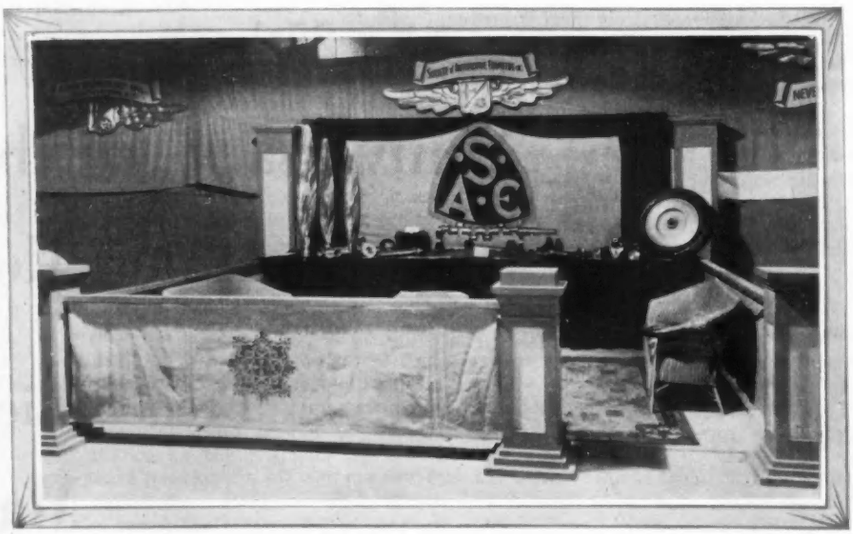
Standards Department Booth at International Aircraft Exposition Spreads Knowledge of Society's Work

PROGRESS made in the aircraft industry during the unprecedented era of expansion that has followed the epochal flight of Col. Charles A. Lindbergh across the Atlantic was exemplified at the International Aircraft Exposition held at St. Louis from Feb. 15 to 23. The 80 or more airplanes exhibited, few of which were designed or planned when Colonel Lindbergh left St. Louis for New York City and Paris in 1927, filled the three huge exposition buildings known as The Arena, recently completed at a cost of $3,000,000. The value of the airplanes and their accessories which were exhibited was estimated by the Aeronautical Chamber of Commerce of America, Inc., the National trade association of the aircraft industry and sponsor of the Exposition, to be in excess of $2,500,000.

By no means least in its appeal, the S.A.E. booth in Building A, in which the Society exhibited numerous examples of standard aircraft parts, was the recipient of interested attention by the throngs of visitors. The exhibits included crankshafts showing the standard hub for mounting propellers, standard magneto-mountings and other physical exhibits of standards that have been developed to provide for the interchangeability of parts and units on aircraft, as formulated by the aircraft industry. The accompanying illustration indicates the character of this feature of the St. Louis Aeronautic Meeting of the Society. Under the supervision of A. J. Underwood, director of the Society's aeronautic activities, it disseminated information to the general public and to aircraft engineers and others regarding the purposes, scope and achievements of the Society.

As the Exposition progressed, thousands visited The Arena to glimpse the scores of brightly painted airplanes that represent the latest products of American aeronautical genius. The formal opening on Feb. 15 marked the climax of many months of work done under the direction of Clifford W. Henderson, manager of the exposition. Each day's session was closed with a spectacular pageant and musical extravaganza depicting the history of transportation and the new spirit of aviation, these being planned and directed by Mr. Henderson.

Among the airplanes on display were many new models shown for the first time, and numerous completely new designs were exhibited also. The new models typified the increase of speed of commercial airplanes during the last year, the 1930 models being from 25 to 50 m.p.h. faster than the airplanes of a year ago. Huge transport-planes capable of carrying a score of passengers stood out in contrast with the small one-passenger sport airplanes, which are smaller than some automobiles.



S.A.E. STANDARDS-DEPARTMENT BOOTH AT THE ST. LOUIS INTERNATIONAL AIRCRAFT EXHIBITION

Committee Meetings at St. Louis

THE Constitution of the Society now requires that each Activity shall elect a Nominating Committee to designate a nominee for Vice-President of the Activity for the ensuing year. Accordingly, nominations and elections of members of these Nominating Committees were made as follows:

Aircraft-Engine-Activity Nominating Committee

At the stated Business Session of the Aircraft-Engine Activity, held Feb. 18, the following Nominating Committee was elected to designate the Nominee for Vice-President to represent the Aircraft-Engine Activity for 1931:

Arthur Nutt, chief engineer, motor division, Curtiss Aeroplane & Motor Co., Inc.

H. K. Cummings, physicist, chief of the automotive powerplants section, United States Bureau of Standards, Department of Commerce.

G. C. Brown, sales engineer, aircraft division, Bohn Aluminum & Brass Corp.

Robert Insley, vice-president, Continental Aircraft Engine Co.

Those nominated and elected to serve as alternates in the absence of the regular nominees were: J. H. Geisse, vice-president of engineering, Comet Engine Corp., and P. B. Taylor, acting chief engineer, Wright Aeronautical Corp.

Aircraft-Activity Nominating Committee

The following Nominating Committee was elected Feb. 19, to designate the regular nominee for Vice-President to represent the Aircraft Activity for 1931:

C. H. Colvin, president and general manager, Pioneer Instrument Co.

Mac Short, vice-president, chief engineer, Stearman Aircraft Co.

J. R. Cautley, in charge of airplane and export divisions, Bendix Brake Co.

C. J. McCarthy, engineering executive, Chance Vought Corp.

The alternates nominated and elected to serve in the absence of the regular nominees were: T. P. Wright, chief engineer, airplane division, Curtiss Aeroplane & Motor Co., and E. E. Wilson, president, Hamilton Standard Propeller Corp.

The first meeting of the 1930 Aircraft-Engine-Activity Commitee was held at a luncheon on Tuesday, Feb. 18. Similarly, the initial meeting of the 1930 Aircraft-Activity Committee was held at a luncheon on Wednesday, Feb. 19. Both Committees laid plans for the forthcoming series of aeronautic meetings and outlined tentative programs for the various sessions to be held at these meetings and at the aeronautic session of the Summer Meeting.

April Aeronautic Meeting in Detroit

FOUR sessions, a banquet, a glider exhibition and an inspection trip comprise the main features of the Detroit Aeronautic Meeting scheduled to take place during the All-American Aircraft Show, which will be held at the Book-Cadillac Hotel, Detroit, April 8, 9 and 10.

Interest in engines burning fuel oils has increased steadily among engine manufacturers during the last year, with considerable progress being made. The first paper of the Engine Session on Tuesday morning, April 8, will be on Improvements in Diesel Aircraft-Engine Development, by Capt. L. M. Woolson, aeronautical and research engineer of the Packard Motor Car Co.

A problem that has confronted the aircraft-engine manufacturers has been the question as to what lines of research and development should be followed to provide suitable engines for aircraft transport - work. First - hand knowledge of what one of the largest operators in the Country feels should be the changes and developments in aircraft engines will be presented by E. P. Lott and Wesley M. Smith, of the National Air Transport, Inc. This paper will give a criticism of present engines from a transport operator's viewpoint, with constructive suggestions as to what might be done to meet the operators' requirements.

The Aeronautic Banquet, sponsored by the Detroit Section of the Society, will be held Tuesday evening in the grand ballroom of the Book-Cadillac, and will be replete with the usual good music and entertainment, which will be followed by an address by a nationally known speaker.

Aircraft and Glider Design

Wednesday, April 9, will be devoted to papers on aircraft design and gliders and to a glider exhibition under the auspices of the National Glider Association. The first paper in the morning session on, How Much Is Lightness Worth in an Airplane, by Edward P. Warner, President of the Society, will deal with weight saving and consequent economies.

The many questions regarding the features of the Curtiss Tanager, winner of the $100,000 Guggenheim Fund Prize for a safe airplane, will be answered in a paper on the construction and performance of this remarkable airplane, to be presented by T. P. Wright, of the Curtiss Aeroplane & Motor Co., one of the designers of the Tanager.

The afternoon will be entirely devoted to gliders. A paper on the design and engineering of glider construction will be delivered by a man prominent in his field, who is as yet unchosen. Following the paper, those who attend the session will be taken in buses to the Municipal Airport, where a demonstration of glider flying will be staged. Plans are being made for shock-cord launched, automobile-towed and aeroplane-towed glider flights. If possible, opportunity will be afforded certain of the members to make short glider flights provided they so desire and if the equipment is available.

It has been possible to arrange for a trip through the Ford Airport, airplane factory and museum. This is scheduled to start on Thursday morning, April 10, from the Book-Cadillac Hotel. The trip will be made by bus and will, in all probability, occupy most of the day, as it has been arranged on the special occasion of this visit of members and guests of the Society to the Museum for the opening of Mr. Ford's village. As this privilege has been granted to very few in the past, it is anticipated that a large number of members will take advantage of the opportunity.

Copies of some of the papers to be presented at this Aeronautic Meeting will be available a few days before the meeting.

The Event
of the Year

S.A.E.

25th

Anniversary Celebration

1930 Summer Meeting

French Lick Springs, Ind.

May 25 to 29, 1930

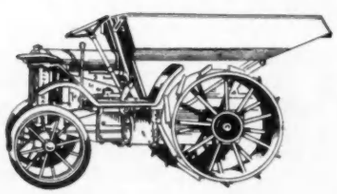
Milwaukee the Tractor Capital

Local Section Entertained by Allis-Chalmers — Problem of Specifications for Heavy Fuel for Tractors Laid at Section's Door

MILWAUKEE'S claim to being the center of the tractor industry was stated by Chairman Arthur C. Wollensak when he called to order the first meeting of the Milwaukee Section in the present calendar year. Within the jurisdiction of the Section, he said, are five large tractor plants and four large manufacturers of engines, besides numerous steel, cast-iron and malleable-iron foundries and drop-forging plants. More than 200 members and friends of the Section were dinner guests of the Allis-Chalmers Mfg. Co. at this meeting, which was held in the club rooms of the plant at West Allis on Feb. 5, following an inspection trip through the plant.

A Nominating Committee for the Section officers for next year was the first order of business, the members selected for this duty being Cyrus L. Cole, William Harley, Arthur Milbrath, Walter Strehlow and Meade Moore.

In a brief opening address, H. E. Merritt, general manager of the tractor department of the Allis-Chalmers company, spoke of the great good that can be done to the tractor industry by the Society, especially in the way of standards. He feels that the responsibility falls first on the Milwaukee Section, because of its position; not only

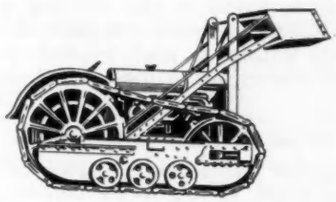


is Milwaukee the center of the American industry, but the United States leads the tractor industry of the world. This leadership is being challenged in other countries and can be maintained only by a leadership of engineers. Lower-cost fuels for tractors Mr. Merritt considers one of the leading problems for the Society and the Section.

Progress in the production of tractors was indicated by Walter Strehlow, an engineer in the tractor department of the Allis-Chalmers company, by a comparison between the machines submitted at the Nebraska tractor tests in 1920 and in 1929. Among the comparisons given were a decrease in fuel consumption from 0.90 to 0.75 lb. per hp-hr., a decrease in weight from 355 to 230 lb. per hp. and an increase in average recommended plowing speed from 2.5 to 3.4 m.p.h. The average weight has been reduced during this period from 8350 to 5970 lb.

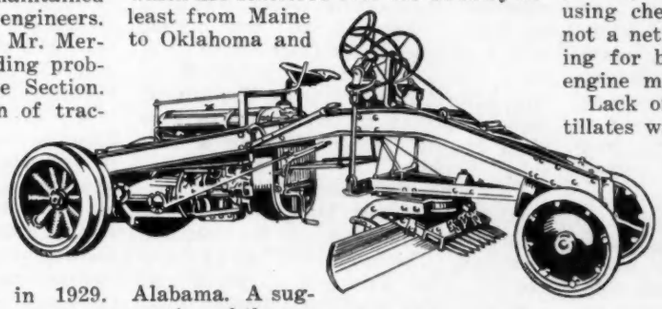
Tractor and Equipment Marketed Jointly

The United tractor, recently produced by the Allis-Chalmers Mfg. Co., is de-



signed to be easily adaptable for many industrial and farm applications. Four forward speeds are provided, of 2 1/3, 3 1/3, 5 and 10 m.p.h. The engine speed can be controlled either by an adjustable governor or by a foot accelerator, and the tractor can be driven as fast as 20 m.p.h. Mr. Strehlow explained the design of this tractor with the aid of a sectional drawing projected on the screen. He mentioned that, whereas cast-iron gears were common in tractors a few years ago, this tractor has alloy-steel gears, entirely enclosed, and alloy steels are used for axle shafts and other parts.

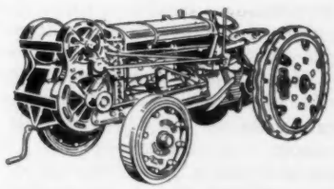
An interesting part of Mr. Strehlow's presentation was the showing of a large variety of adaptations of the United tractor, such as a crawler unit, road graders, snow-plows, cranes, shovels, hoists, "iron mules" and locomotives, which are built by the Allis-Chalmers company and the dozen or so other manufacturing members of the United Tractor & Equipment Corp., which are scattered over the Country at least from Maine to Oklahoma and



Alabama. A suggestion of the variety of these units is given in the drawings reproduced herewith.

Called upon for discussion, J. C. Slonneger, of the International Harvester Co., said that most tractor engineers have overlooked the comfort of the operator. The tractor is not a pleasure vehicle; the passenger gets no pleasure from riding on it. It may be impracticable to use springs at the rear, but springs at the front would add considerably to the comfort, and a chance to stand would afford real relief to the operator who gets tired of sitting in one position hour after hour. Mr. Slonneger also objected to the continual process of adding "gadgets" to tractors and suggested that the water-pump might be eliminated, with a reduction in heat loss.

Two dividends of the manufacturing, engineering and sales departments were alluded to by R. R. Keith, of the J. I. Case Co. One of these dividends



accrues directly from building the product, and the other and more permanent return depends upon the interchange of ideas secured by visits and talks.

Heavy-Fuel Tractors Demanded

Kerosene and distillate as tractor fuels were discussed briefly by C. E. Frudden, an Allis-Chalmers engineer, who said that many tractors must be designed to burn fuels that are heavier and cheaper than gasoline to meet the requirements of the present tractor market, especially the export market. A farmer who is using 40 gal. of fuel per day can save $2 to $4 per day by using cheaper fuel. While all this is not a net saving, it is well worth trying for but presents a puzzle to the engine manufacturer.

Lack of uniformity in so-called distillates was mentioned by John Huber, of the Le Roi Co., as a main difficulty in their use. Various brands in different parts of the Country present varied problems. Standardizing the flash-point, initial boiling-point and end-point of distillate would offer a beginning.

A happy contrast to the experi-

menter who claims everything was afforded by L. M. Ward, of the Rector Gasifier Co., who said that none of the many devices for burning kerosene that have been tried and patented have been successfully developed. He did not except the gasifier with which his own company is attempting to burn heavy fuels, with the aid of direct heat from a fire within the mechanism to convert the fuel into a different state before it enters the engine.

Oil-Engine Experiences and Opinions

The possibility of using Diesel engines for tractors having been mentioned, Chairman Wollensak called upon C. L. Cummins, of the Cummins Engine Co., as the man who got on the front page of the New York City newspapers at a cost of only $1.38 for fuel oil. Mr. Cummins gave a very interesting account of his trip from Columbus, Ind., to New York City and return with an ordinary passenger-car in which had been installed a Diesel engine of his own make. This account may be expected to appear in an early issue of the S.A.E. JOURNAL.

The difficulty in defining distillate was illustrated by A. W. Pope, Jr., when he quoted the chief chemist of one of the larger oil refiners as saying that he considers distillate to be "anything that is left over." Investigation by the Waukesha Motor Co., with which Mr. Pope is connected, showed that the difference in production cost between gasoline and heavier oils is only about 1½ cents per gal.; the greater difference in selling price is largely artificial, based on marketing conditions. He said that kerosene is one of the easiest fuels to burn in a carbureter engine but causes excessive knocking. However, refiners are on the eve of being able to supply large quantities of fuels conforming to any intelligent demand of the engine users.

Russian kerosene has been used in a number of engines exported by the Wisconsin Motor Co. to Russia. Some of this kerosene, which was supposed to be of a better grade than the American product, was tried at the Wisconsin factory, according to A. F. Milbrath, and was found to create such intense heat that it was possible to burn up the cylinder-head, under certain conditions, in a single day. Combustion-chamber design, and especially manifold design, makes a marked difference in burning kerosene. Mr. Milbrath reported obtaining within 5 per cent as much power from kerosene as from gasoline, with manifolds of certain types.

Mr. Slonneger expressed interest in the application of Diesel engines to tractors, saying that flexibility is not needed in a tractor engine and mentioning the freedom of the Diesel engine from crankcase-oil dilution and the reduced need of cooling. Mr. Merritt remarked that hearing Mr. Slonneger twice had persuaded him that Mr. Slonneger is a salesman and not an engineer. Diesel engines were installed in six Monarch-75 tractors last summer, and men had been "gum-shoeing" around ever since trying to get fuel that was just right to use in those engines. Mr. Merritt threatened Mr. Cummins with physical injury if he interrupted the statement that Diesel-engine designers must disabuse their minds of the idea that they can use butter, axle grease or anything else as a fuel. One Diesel engine enthusiast from Honolulu has reported that, whenever the fishing boats there get out of oil, they catch a few fish, render the oil from them and come home on it. Arrangements must be made for something like a standard fuel. Mr. Merritt concluded by saying that the only right he had to speak in this meeting was that it had cost his company about $30,000 within a year to find that Diesel engines are subject to oil dilution.

Diesels Defended from Attack

Heinrich Schneider, of Fairbanks, Morse & Co., sprang to the defense of Diesel engines. If they cannot be operated without dilution in the crankcase, he asked, how can they make records such as have been made in France, of running 24 hr. per day for 260 days without any shut-down? Diesel engines on transatlantic liners and boats sailing from Denmark and Sweden to India and China have no trouble with dilution. The low cost of the gasoline engine and its familiarity Mr. Schneider considered to be the reasons for the Diesel engine having been so little adopted for tractors. Inexperienced men may have discouraging troubles with them, but he predicted that in time some company will find a profitable market for tractors equipped with Diesel engines.

Crankcase-oil dilution is hard to prevent in a Diesel engine unless a considerable excess of air is supplied in the charge, asserted Mr. Slonneger. He recognizes that many problems remain to be solved with the Diesel engine, but they are not impossible of solution.

An investigation was called for by J. B. Fisher, of the Waukesha Motor Co., to determine why a farmer buys a kerosene tractor and then burns gasoline in it. He nominated for the job the Waukesha boy who finished high in his class in a course in pharmacy, and then lost his job in a Chicago drug store because he could not make sandwiches. He said that an engine must be designed for the fuel it is to burn; not merely adapted by hanging onto it a kerosene attachment of some kind. He called for the "poor farmer" to serve as a star witness in the investigation.

Metallurgy and Properties of Steel

Oregon Section Hears a Comprehensive Treatise by Prof. S. H. Graf and Inspects Exhibits

KEEN interest of the members of the probationary Oregon Section in the subject at their second meeting was made evident by the prolonging of discussion until 11:45 p.m. and the remaining of many until after midnight to view exhibits placed in the Multnomah Hotel by the Oregon State College and three manufacturing companies.

More than 80 members and guests attended the meeting, which was held on Friday, Feb. 14, and was opened with a banquet in the Chamber of Commerce dining-room in the hotel. Music and entertainment during the dinner were furnished by an orchestra supplied by the Oregon Welding & Machine Works.

Following the dinner, a short business meeting was held, with A. R. Trombley, Chairman of the Section, presiding. The minutes of the January meeting were read and approved and a motion was made and passed complying with the request of the Council of the Society to change the name from the Portland Section to the Oregon Section. Appreciation was expressed to the exhibitors for donating and arranging the displays, and, on behalf of the Section, Chairman Trombley welcomed the guests present and extended an invitation to become members, enjoying thereby not only the future meetings but many other advantages to be gained.

After a brief intermission, Vice-Chairman H. W. Drake spoke briefly on the advantages to be gained by the man who will make the effort to study subjects allied to the job he holds. Pointing out, as an illustration of this, how little effort was required to secure the valuable information contained in the address about to be presented and how quickly that information can be applied to automotive work, Mr. Drake introduced the speaker of the evening, Prof. S. H. Graf, director of engineering research at Oregon State College.

Professor Graf had selected for his subject, Automotive Steels and the Fun-

damentals of Their Heat-Treatment, which was adequately illustrated by lantern slides. In treating this subject, Professor Graf began with a brief résumé of the history and development of the iron industry from the first crude furnaces to the modern blast-furnaces. Next, the principles of metallurgy as applied to the ferrous metals by means of microscopic examination, pyrometers, and other instruments were shown. Then the methods of testing steels for physical properties, such as stress resistance, ductility, hardness, resistance to repeated stress, and the relation of these properties to specific requirements in construction were given.

The speaker then brought out the structural and chemical differences between wrought iron, plain carbon-steel, alloy steels, cast iron, malleable iron and cast steel. Applications of these different ferrous materials in structures and machines were cited, and the reasons why each material is best suited for its particular function were enumerated. Methods of case-carburizing and nitriding were discussed and the effects of the processes illustrated with micrographs.

The S.A.E. system of designating the different alloy steels by numbers was explained and some of the different suggested heat-treatments were discussed in relation to the physical properties brought out by them.

Slides showing some of the different equipment installations for commercial heat-treating were accompanied by an explanation of the metallurgical principles upon which the various methods are based. Other slides illustrated equipment for testing the degree of hardness of steels.

A lively discussion followed the close of the address, during which many of the members were enabled to clear up points of doubt and many other points were brought out more fully than during the lecture.

Exhibits previously placed in the hotel included a recent type of metallograph and prepared specimens, shown by Oregon State College; a complete line of 100 or more socket wrenches and other hand tools made by the P. & C. Tool Co.; a line of tool and alloy steels, heat-treating equipment and hardening equipment, shown by the Pacific Machinery & Tool Steel Co.; and exhibits by the White Co. showing all of the steps in forging from the billet and finishing a transmission gear.

Business of Engineering

STUDENTS of the General Motors Institute of Technology who are members of the Flint, Mich., Student Branch of the Society, listened to an interesting and informative talk on the Business of Engineering, by F. C. Hecox, administrative engineer of the Cadillac Motor Car Co., at the meeting of the Branch on Feb. 12. Major Hecox traced the development and organization of the Cadillac engineering department, presented a complete picture of the purposes and broad scope of the Society, and by participation in the discussion that followed was able to satisfy the student interest in present engineering problems.

The technical session followed a splendid dinner. Several new members were welcomed into the Branch, taking advantage of their eligibility as members of the junior class at the Institute to become S.A.E. Student Members. Chairman Earle Williams presided.

In concise, instructive talks, two members of the faculty of the Institute emphasized the advantages to be derived by engineering students from affiliating themselves with a prominent engineering society. One of the speakers was Guy R. Cowing, assistant director of education at the Institute. The other was H. R. Spahr, formerly of the Society for the Promotion of Engineering Education, in charge of the study of industrial requirements for technically trained men, and now in charge of curriculum and industrial development at the General Motors Institute of Technology.

Canadians Consider Own Problems

Enthusiastically Endorse H. D. Allee's Suggestions Regarding General Use of Standards

WITH the example before it of what has been achieved in the United States, the Canadian Section, after a spirited discussion on the necessity for standardization in Canada, decided at its monthly meeting at the Royal York Hotel in Toronto on Wednesday, Feb. 19, that it was high time some forward steps were taken. Chairman R. H. Combs therefore undertook to place in the hands of the leaders of the motor-car industry in Canada copies of the address by H. D. Allee, with the request that the suggestions made in it and in the subsequent discussion be given earnest consideration.

Mr. Allee, who is production manager of the Studebaker Corp. of Canada, touched first on the major forms of standardization; namely, S.A.E. Standards, unification of design, and the universal marketing and selling of standardized products.

The industry, he said, has still a long way to go before it takes full advantage of the S.A.E. Standards. In Canada, much has still to be done with standard steels; the automotive industry is relatively small and hence tool costs are a great factor.

Advocates Using Substitute Standard Parts

As regards unification of design, Mr. Allee urged that every subsidiary company in Canada should be permitted to use a substitute S.A.E. Standard design, instead of adhering to the individual design of the parent companies in the United States. This would not complicate service parts, he argued, because parts built to S.A.E. Standards are procurable everywhere throughout the world. He pointed out that opportunity exists for much unification without sacrifice of individuality of design, and cited as an example a distinctive head-lamp which could, however, be mounted on a standard head-lamp base. One of the most gratifying recent advances in Canada, he said, was the adoption by three large concerns of the same wire wheel. When mounted on a dozen different cars, with different hub covers, this became 12 different wheels. The only parts of a car that call for individualism, said Mr. Allee, are body shells, fenders, hoods, frames, engines and radiators. All the remaining parts, he believes, might be standardized, and he said he hopes that a representative gathering of interested Canadian engineers will be called in the near future to get under way on this most important function.

Coming to his third point, of marketing and selling, Mr. Allee deplored the lack of sales engineers by parts makers. This has a stifling influence on the industry as a whole. Parts makers in Canada need to follow the example of the United States and build up volume sales of a standardized product among a large variety of manufacturers. The industry in Canada, he stated, is ideally situated for sales engineering because there were only two centers of importance, Toronto and the border cities, and owing to this proximity business would be expedited between manufacturer and parts maker.

In conclusion, Mr. Allee said that the automotive industry in Canada has been in a condition of "feast or famine," owing to volume fluctuation and weather conditions. Nothing can be done about the weather, but much can be done about volume, because standardization and distribution are creators and regulators of volume.

Model Changes and Tariff Discussed

In the discussion which followed, the meeting as a whole heartily endorsed

the points brought forward by Mr. Allee. One member remarked that the frequent changes in cars react badly on the parts makers, and that this is a field in which the manufacturers might cooperate.

Mr. Allee commented that the further one gets from the American car the less subject he is to change. He mentioned that of five recent changes made by his own company in the United States, three had not been touched at all by the Canadian company. "We are far enough away," he remarked, "to forget the little knick-knacks they put on."

The question of the tariff also came up, as offering a solution to some of the troubles of parts makers and manufacturers; but it was felt that there was little prospect of relief from that quarter.

Considerable discussion followed anent the difficulty of Canada, with its 9,000,000 population, competing with the United States, with its 120,000,000. The ratio of 13 to 1 in favor of the United States is further increased when it was considered that nearly 50 per cent of Canadian production is for export, and that on this export trade most of the material is imported first from the United States, on account of the drawback allowed by the Canadian tariff on goods imported for re-export.

The meeting closed with a resolution, moved by N. P. Petersen, of the Canadian Acme Screw & Gear Co., and seconded by A. H. Woods, of General Motors of Canada, that copies of Mr. Allee's address be furnished to Canadian manufacturers and the Chairman urge upon them the need for concerted action along the lines indicated.

Groundwork of Aviation

THE Northwest Section held a meeting on Jan. 18 at the Gowman Hotel, in Seattle, Wash., at which Walter R. Jones explained the fundamentals of aviation in a very thorough and comprehensive way with the aid of blackboard sketches. He began by listing the four types of aircraft as lighter-than-air craft, ornithopter, helicopter and airplane. In the present state of the art, he can see no likelihood of commercial mechanical flight being successful with either the ornithopter or helicopter, although helicopters have been constructed that have risen from the ground and flown short distances.

Beginning his exposition of the airplane with the wings, Mr. Jones said that about 75 per cent of the supporting effect of a well-designed wing comes from the vacuum produced at its upper side. Biplanes have structural advantages, at the expense of wing interference which makes the supporting value of two wings equal to about 1.9 times that of one wing. Stagger can be used to minimize interference, and it has also an influence on visibility from the pilot's seat.

The relative advantage of air-cooled and water-cooled engines was weighed, with a word for the possible advantages of cooling by means of a liquid having a boiling-point higher than that of water. Metal propellers were said to be about twice as heavy as those of wood but slightly more efficient and much more durable. Jet propulsion was mentioned, but not hopefully.

Stability and Controllability Opposed

Longitudinal, lateral and directional stability was explained, and the means for securing stability of each of the three kinds were outlined. It was made clear that stability and controllability are opposing qualities; a stable airplane is desirable for transport work but would be useless for fighting, while a plane having the ease of control required for combat service would not have sufficient stability for commercial use.

After explaining seaplanes, flying boats and amphibians, Mr. Jones stated the four principal factors involved in airplane design to be weight, wing area, power and fineness; and he said that the preference depends mainly upon the ratio of weight to wing area and weight to total power.

Wing loading ranges from 6 to 25 lb. per sq. ft., the latter figure applying to the fast racing planes. The customary loading was said to be between 10 and 15 lb. Landing speed is governed by the wing loading; and, as few pilots like to land airplanes at speeds higher than 60 or 65 m.p.h., the wing loading cannot be extremely high.

In conclusion, Mr. Jones said that airplane design is far from its ultimate stage and he is unable to predict what new thing will be developed from the many radical designs upon which engineers are working; but none of these radical departures seem now to hold promise for the future.

Electrons Parade for the Ladies

Advanced Vacuum Tubes and Theramin Demonstrated at Detroit Ladies' Night

LADIES' Night dinner at the Detroit Section drew an attendance of 577 on Feb. 17; the gate crashers were not counted. Necessary business was quickly disposed of by the election of a committee to make nominations for the Section officers for the coming year. The members of this committee are W. R. Strickland, Robert Insley, James M. Crawford, Carl B. Parsons and Walter T. Fishleigh.

As the program was based on electrical phenomena, electrical executives of some of the car companies were invited to dress the head table. Chairman L. Clayton Hill introduced them for bows: Vice-Chairman P. J. Kent, of the Chrysler Corp., who was responsible for the arrangements for the meeting; Frank Wager, of the Studebaker Corp.; J. E. White, of Dodge Bros.; Frank Asire, of the General Motors Corp. Research Laboratories; A. A. Leonard; A. R. Lewellen, of the Chevrolet Motor Co.; Charles Vincent, of the Packard Motor Car Co.; H. Schwarze, of the Oakland Motor Car Co.; and Mr. Thomas, of the Ford Motor Co.

Three numbers were played on the Theramin by Howard Minor, of Grinnell Bros., who furnished this instrument and also the Victor Radiola, which played during the dinner through a Vitaphone horn. Mr. Minor was accompanied on the piano by Miss Carron, and he explained the operation of the Theramin. The Kunsky Theater loaned the sound apparatus that was used in connection with the motion pictures.

The Private Life of the Electron was the announced title of the very entertaining talk given by Ellis L. Manning, a research physicist with the General Electric Co. in Schenectady, one of whose duties, according to Chairman Hill, is to guide Floyd Gibbons through the laboratories and feed him the pap on which his weekly General Electric talks are based. As an opening gesture, Mr. Manning decorated Chairman Hill with an invisible medal as a distinguished scientist for his discovery that the electron is of the feminine gender. This discovery is substantiated by the fact that men cannot get along without electrons and sometimes cannot get along with them.

The filament of an ordinary incandescent lamp is evaporating electrons at a tremendous rate, said Mr. Manning. In the social life of the electron, as in that of a human being, opposites attract. The electrons carry a negative charge, and the X-ray tube was born when W. D. Coolidge discovered that a positively charged plate inside the bulb would attract them. The addition of a third piece of metal, called a grid, was the key to the radio tube. A motion picture was presented to show how the energy received from an aerial is applied to the grid of a radio tube to control the current which reproduces the original sound waves.

A small transmitting set was exhibited by Mr. Manning, and some visible disturbances caused by its tube were demonstrated. He mentioned as prac-

tically accepted the theory that the structure of the atom resembles that of the solar system and said that some of the physical effects of exciting an atom are supposed to be parallel to what would happen if the earth or one of the other planets should be moved a few million miles farther away from the sun and rotated in its normal way. An atom from which one of the electrons has been removed is called an ion and is positive, because the central sun of the atom is positive and each of the electrons is negative, and removing part of the negative charge leaves a net positive charge. The action of the tubes filled with gases such as neon and helium was demonstrated in this connection.

Electric Eye Watches the Makings

Next shown was the combination of a photoelectric cell, which is sensitive to light, and a thyratron tube, which might be described as a switch that can be opened and closed by the photoelectric cell. This combination is used in reproducing sound that is photographed on a film. It is also used to actuate a mechanism for counting the cars that pass through the Holland Tunnel, to regulate the shade to which food products are browned in toasting and to control a plunger which picks off from a conveyor belt yeast cakes that have not been supplied with the yellow label that is considered proper and fitting in the spheres in which yeast cakes circulate.

Mr. Manning described another use for the so-called electric eye that he demonstrates in his room in Schenectady. The apparatus represents a control for the ventilators of the Holland Tunnel, which is to make the ventilating fans operate only when the atmosphere is smoky. The device functions under the influence of the amount of light that passes across the tunnel when the air is clear or smoky. As cigarette smoke is used in the demonstration, Mr. Manning reaches for a Lucky instead of a switch.

ELLIS L. MANNING

Short Waves May Cure Fever

Dr. Whitney, director of the General Electric laboratory, was quoted in connection with Mr. Manning's last topic as saying that progress in science depends upon having a trained observer on hand when Nature does something unusual. In experimenting with oscillators producing short wave-lengths, workers noticed uncomfortable heat in their legs and suffered from headaches. Shielding allowed the work to continue, and investigation disclosed that these short waves would heat the blood without heating the body. Dr. Whitney says it is possible to heat a barrel of beer inside a load of hay, or to roast peanuts without heating the shell.

Speculation on this phenomenon points to the possibility of important therapeutic value, which has not yet been sufficiently demonstrated. Theory has it that fever is a natural attempt on the part of the body to destroy invading germs by means of heat. This causes a heavy drain on the bodily energy of the patient, and it may be that short-wave apparatus can supply the needed energy and save the energy of the patient. Some successful experimenting has been done on infected animals, but the application of anything of this sort to human beings must proceed very slowly.

Before swinging into the dancing, which lasted from 9.30 to 12.30, Chairman Hill announced Paul Henderson as speaker for the Aeronautic Meeting of the Section on March 3, and Raymond Hood for the 17th-of-Ireland Meeting of the "body crew." Mr. Hood, who was the architect of the Tribune Tower in Chicago and the American Radiator Building, which raises its black and gold top over 40th Street in New York City, will give a talk on beauty in automobiles.

Variety in Aeronautics

Safety in Aircraft the Principal Subject at Dayton—Talks on Autogiro and Instrument Flying

ADDRESSES on three aeronautic subjects, lantern slides of foreign and American entries in the recent Guggenheim Safe-Airplane Contest and a motion picture of the Curtiss Tanager airplane, winner of the contest, were the attractions offered at the meeting of the Dayton Section on Feb. 13. The dinner at the Engineers' Club, which preceded the meeting, was attended by 16 members and guests and the attendants at the meeting, which was presided over by Chairman F. W. Heckert, numbered 50. Bradley Jones, professor of aeronautics at the University of Cincinnati, was the principal speaker, his topic being Safety in Aircraft. E. A. Johnson, president of the Johnson Airplane Supply Co., of Dayton, related his experience as a passenger in the Autogiro and Lieutenant Brookley, of the Army Air Corps, gave a short talk on Instrument Flying.

How Airplanes Have Been Made Safe

Although the problem of safety in aircraft may seem to have been solved, said Professor Jones, many difficulties remain to be cleared up before the greatest possible degree of safety is attained. Some of these are the hooded cockpit, means for correcting the altimeter in flight and installing radio equipment on all airways and on airplanes to reduce the danger of flying in fog.

Stating that an airplane is not safe unless an inexperienced pilot can handle it, the speaker said that in planning the Guggenheim Safe Airplane Contest an effort was made to devise a set of rules that could be complied with by an airplane that was safe for a pilot who had only limited flying experience. These rules required a contestant to fly at a speed of 35 m.p.h., glide under perfect control with the power off at 38 m.p.h., take off in 300 ft. and clear a 50-ft. obstruction, land within 500 ft. of the starting point and stop dead within 100 ft. of where the wheels first touched the ground, take off in an area 500 ft. square without passing through any of the obstacles surrounding this area, turn around and land within this square without going through the sides when the engine is cut off at any time; in addition, the airplane must have a maximum speed of at least 110 m.p.h.

Only 1 of the 26 entrants in the contest, the Curtiss-Tanager entry, passed these rigid tests. This was a biplane with flaps on both wings and novel floating ailerons. The latter were designed like weathervanes and automatically adjusted themselves so as to be parallel with the air meeting the wings. This was a rather new invention and purely a development for this airplane, said Professor Jones, who described the airplane as a combi-

THE CURTISS-TANAGER AIRPLANE
This Biplane Was the Only One of the 26 Entrants in the Guggenheim Safe Airplane Contest To Pass All of the Rigid Tests Successfully

nation of slotted wings, flaps and floating ailerons possessing wonderful control. Brief descriptions of the various airplanes entered were also given and lantern slides of them were shown.

Increasing the angle to which the airfoil can be tilted is a safety measure, and the most popular method of doing this is by using slots. At this point in the paper, Professor Jones illustrated by freehand sketches the use of slots and the effect of different wing curves.

Commenting on the difference between airplane speeds in the United States and abroad, the speaker said that the slower speed in this Country is no disparagement of the American airplane designers; on the contrary they pay more attention to safety in landing than do their foreign contemporaries. He regards 75 m.p.h. as the maximum safe landing-speed, while in Italy the landing speed for racing airplanes is approximately 130 m.p.h. and, because of their small wing-area, the airplanes will crash if flown any slower when landing. This speed Professor Jones believes is too high for landing, since too many accidents had occurred at this speed. An arrangement that will support an airplane at low speeds is needed but is not required after high speed has been attained.

Flight Experiences with the Autogiro

Responding to a call by Chairman Heckert, E. A. Johnson described his recent flight in an Autogiro. The most noticeable feature about the flight, to his mind, was the necessity in taking off to taxi the entire length of the field and back again to attain the necessary speed of the rotating wings for lifting the machine.

Although the Autogiro is, in his opinion, too queer looking to be popular for commercial pleasure use, its ability to land virtually everywhere, even among trees or rocks should the occasion arise, renders it suitable for flying over bad terrain and in bad weather. He gave this as the reason for its manufacture by Pitcairn Aviation, Inc., the operator of the New York City-Atlanta air-mail route. Fields in which the Autogiro has great possibilities are the transporting of mail and night flying.

Instrument-Flying Problem Not Solved

Instrument flying will never become really popular, said Lieutenant Brookley, of the Army Air Corps, although it has its place and should be perfected. For safe flying, 20 per cent training and 80 per cent good judgment are necessary. The latter will carry a poor pilot a long way, whereas poor judgment will kill off a good pilot in a short time.

The Army Aviation School requires at least two years to perfect a pilot, continued the speaker, as time is essential to develop that inherent instinct whereby a pilot will correct a mistake without thinking about it first. While instruments make blind flying safe, extreme self-discipline by the pilot is necessary.

The instincts must be governed and flying must be mechanical, a procedure that is difficult and requires long work and practice. The mechanical pilot is a good example of instrument flying and on a rough day it will fly an airplane much smoother than is possible by hand. For really bad weather, instrument flying is much the better method, although it is of no use in ordinary flying under ordinary conditions.

Hoosiers' Annual Show Review

D. G. Roos Discusses Engineering Developments and H. C. Snow Describes Car Improvements

CHIEF engineers of two automobile companies told 200 members and guests of the Indiana Section, who gathered in the Chateau Room of the Claypool Hotel in Indianapolis on the evening of Feb. 13, what was what and why in the cars exhibited at the Automobile Shows in New York City and Chicago this winter. Delmar G. Roos, chief engineer of the Studebaker Corp., reviewed the engineering developments, and Herbert C. Snow, of the Auburn Automobile Co., outlined the trend and described some of the interesting features.

Mechanical Developments Reviewed

While marked progress has been made in 1930 cars, Mr. Roos said that room for further improvement exists. As an example of this, he mentioned the growing use of independent wheel-suspension in European cars, which he believes typifies real progress. Certain engineering features such as the use of valve monitors in the 16-cylinder engine were highly commended. These monitors make the push-rods self-adjusting and would, if they prove successful in long-continued operation, overcome the most serious drawback to overhead push-valve engine mechanism. Revival of the 12-cylinder car was also mentioned as a possibility in the trend toward more cylinders for passenger-cars. Such a revival would now be possible, owing to improvements in carburetion and manifolding, although at the time of its appearance a few years ago the car was ahead of its time.

Progress toward Smoothness and Quietness

Rubber mountings of engines were among the very obvious things at the shows, the use of this feature of design having carried the smoothness of the job far beyond that point which merely balancing of parts could bring about. Torsional vibration, that bugbear of the past, has been dealt another blow by decreasing the length of the stroke.

Although the rear-axle situation

might be said to show no marked improvement, this, in Mr. Roos's opinion, is due to the fact that, while rear-axle gears undoubtedly are being improved, the standards of the public are becoming more exacting and the situation is made more acute by the fact that the other mechanisms of the car are constantly becoming quieter.

Brakes were steadily improved in the last year, the most important advance being the development of cable controls for mechanically operated brakes, which not only eliminate virtually all the geometric problems introduced by axle roll and spring movement but also are free from the rattling that characterizes almost all rod and lever installations. An interesting phase of brake development is its transfer from the chassis builder into the hands of specialists.

Friction-type shock-absorbers have been almost completely displaced by the hydraulic type, according to Mr. Roos. Here room for improvement exists, one point that was mentioned being the elimination of hydraulic noises. As considerable research work is being done along this line, the speaker looks for the solution of the problem before the 1931 cars make their appearance.

Downdraft versus Updraft Carburetion

Last year witnessed the advent of the downdraft carbureter which was supposed to give more power. While in a number of cases this was true, it was accomplished, Mr. Roos said, only at a decided sacrifice in low-speed operation. In some cases manufacturers who installed downdraft carbureters found that the addition of more heat to the manifold and a reduction of the size of the venturi were necessary. Where maximum performance is sought on straight-eight-cylinder engines, the duplex carbureter and manifold are definitely required and the results are better than those obtainable with the single carbureter. The vacuum tank has been almost entirely displaced by the fuel-pump, which is an improvement especially from the viewpoint of idling and operating in mountainous countries.

More new models were exhibited at the shows than for a number of years, but few of these, said Mr. Snow, showed really radical changes in design, most of the changes being in the details. The two outstanding changes were the Cadillac 16-cylinder engine and the front-drive cars. More 8-cylinder cars were shown this year than ever before, 27 companies building this type, 23 producing 6-cylinder cars, 3 building 4-cylinder cars and 1 having produced a 16-cylinder car.

Almost all engines have been increased in size, seven models with a piston displacement of 300 cu. in. or more and two exceeding 400 cu. in. being shown. Increased stiffness, which tends to eliminate torsional-vibration trouble, results from heavier crankshafts and a shortening of the stroke in proportion to the bore. To eliminate crankcase vibration, said Mr. Snow, longitudinal ribs are placed near the center, and on one eight-cylinder engine the water-jacket is brought down to the bottom of the piston travel.

Increased power-output has added to the difficulty of keeping the oil temperature low. Longitudinally ribbed aluminum lower halves of the crankcase are used on some cars. In one of the new models a section in the radiator acts as an oil-cooler and the oil is circulated through it by one unit of a double pump that is mounted in the crankcase sump, the other unit circulating the oil through the engine. High pressure in the radiator core when the oil is cold is prevented by the installation of a relief valve. On another car a spiral-gear pump that is said to deliver twice as much oil as the one it replaces has been installed. Splash-type lubrication has been retained on one of the eight-cylinder cars, an oscillating and reciprocating pump that eliminates the check valves being used to force the oil to both ends of the crankcase, while the oil as it flows back toward the center feeds the pockets over the main bearings and also the troughs.

Larger Carbureters Increase Power

Carbureters are larger on the new models in response to the constant demand for increased power, said the speaker. The downdraft grid is installed on a number of cars and one of these has a duplex downdraft type which is claimed to give considerably more power and also improves the exhaust-manifold design, as the outlet is located in the middle instead of the end, thus affording a better opportunity to apply heat around the carbureter.

Virtually all cars have some form of control for heat around the manifold. Many of these are interconnected with the throttle, and a dash adjustment is provided to meet seasonal conditions.

Transmissions show marked improvement, many of the cars having the internal-gear four-speed type. On one car a three-speed transmission with helical gears that are always in mesh is used. This has an engaging dog between the two gears, which is very similar to the internal-gear three-speed type and is easier to shift than the conventional transmission.

Rubber Mountings and Bushings

Frames have been straightened, Mr. Snow said, especially since rubber engine mountings have come into extensive use. Tubes for cross members are becoming rarer, although they are still used at the front end. A rather unique construction is used on one of the cars in which a special feature is a plate with the flanges turned over and having a hole through the center which is large enough to permit assembling the transmission through it. Reinforcing sections in the side rail characterize many of the cars.

Rubber is used in the spring bushings on a large number of cars. A special type of such bushings used in one car consists of an outer tubular steel shell and a small inner steel tube with a large rubber bushing forced under high pressure into the intervening space. The forcing must be done quickly to compress the rubber sufficiently to fit into the small space, and when the bushing is assembled the contact between the rubber and the steel is almost as intimate as if the former had been vulcanized to the latter.

A slightly different construction on another car has conical steel cups with a hole in the center inserted in the spring eyes. A conical bushing is inserted into the cup, the sides of the spring shackles bearing against these bushings, and the bolt which passes through the central hole expands the bushing into the cup, thus giving a very strong contact between the bolt and the rubber and between the rubber and the outer shell.

In closing, Mr. Snow suggested that the shows would have a greater educational value for engineers if the practice of showing a cutaway chassis became more general, as many of the interesting features are covered up by the hoods and bodies of the cars that are exhibited.

The March meeting of the Section will be held on the 13th, the subject being Advances in Automobile Lighting. The speakers had not been announced at the time of going to press.

University of Detroit Student-Branch Meeting

MEMBERS and guests of the University of Detroit Student Branch of the Society were offered an opportunity, at the regular meeting on Jan. 31, to become familiar at first hand with the new Cadillac 16-cylinder V-engine car. The meeting was held in

the new Cadillac engineering building, through the courtesy of F. C. Hecox, administrative engineer of the Cadillac Motor Car Co. Members of the General Motors Institute of Technology Student Branch and students from the University of Michigan were present as guests of the University of Detroit Branch and helped to make the meeting enthusiastic and well-attended.

All those present were given a long ride in the new car and, while some were riding, others were examining engines undergoing various tests in the engineering building. Some of the more important engineering features of the car were explained briefly by Mr. Hecox, who then led the visitors on a tour through the whole building, which is equipped to build a complete automobile from the drafting board to the finished product. The tour ended when the guests came to two cars, one complete except for the body, and the other entirely taken down. Here nearly an hour was spent in minutely examining these cars and questioning Mr. Hecox with regard to them.

Metropolitan Movies of Standards

Men and Machinery of the Government Bureau Shown in Action at Section Meeting

DR. H. C. DICKINSON presented Cine-Kodak pictures representing a visit to the Bureau of Standards in the City of Washington at the meeting of the Metropolitan Section in the A.W.A. Clubhouse in New York City on Feb. 20. He described the performance as a movietone, Eastman furnishing the movie and Dickinson the tone.

At the close of the usual dinner, Frederick K. Glynn introduced Dr. Sanford Culver Hearn, who is a social service worker in one of the gangster neighborhoods of Brooklyn. Dr. Hearn gave a very entertaining talk on the cheerful-sounding subject of epitaphs, and quoted a large number of amusing inscriptions that he has personally gleaned from gravestones in the Eastern part of the Country. These were divided into classes in a systematic manner, and samples of each class were given. One representing frank comment on the character of the departed was:

> Owen Moore has gone away
> Owin' more than he could pay.

Following Dr. Hearn's talk, Vice-Chairman John F. Creamer introduced J. W. Florida, general manager of the new Packard service station in Manhattan, who is scheduled as the principal speaker at the March meeting of the Section, which is to be held on the 20th in the Packard plant at 54th Street and 11the Avenue. Next came the election of a Nominating Committee for next year's Section officers, consisting of A. M. Welch, A. C. Bergmann, Henry R. Cobleigh, Louis J. Heinrich and Lars G. Nilson.

Outside and Inside Views

Dr. Dickinson opened his presentation with an airplane view of the buildings and grounds of the Bureau of Standards and said that when he joined the Bureau in 1903, he was the third man in the Division of Heat. The Bureau then comprised five divisions and about 25 people. Now the same division, of which Dr. Dickinson has become the head, consists of more than 200 Government employes and about 25 research associates. The Director of the Bureau, George K. Burgess, who was shown first in the motion pictures, joined the Division of Heat about a week before Dr. Dickinson. The reel showed the heads of several of the divisions in action and also apparatus and tests in many parts of the institution. Poor lighting detracted from the clarity of some of these pictures, but still they showed much of interest. One of the rooms shown contained a number of women who were testing thermometers, a job which is done for outside parties to the extent of $30,000 per year. In an adjoining room, 150,000 clinical thermometers are tested every year.

A motion picture of molten iron in a crucible promises little of interest, but Dr. Dickinson pointed out sudden changes of brightness on the surface, which, he explained, were due to the quick formation of a film of oxide. This phenomenon, which occurs in certain irons at a temperature above the pouring-point, makes an apparent difference of 75 deg. in temperature as determined by a pyrometer, causing an inaccuracy in the reading that is too great for control of the production of good castings by this means.

Aeronautic Research Visualized

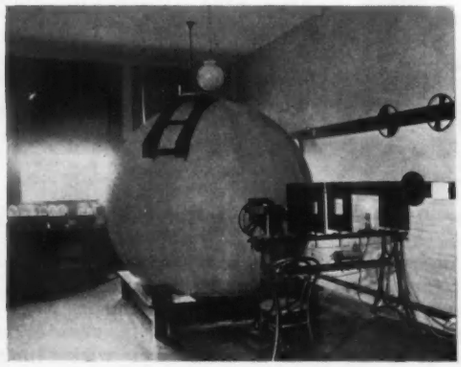
Among the apparatus shown in action were an extremely sensitive recording seismograph, together with some of its records; an air liquefier; a 200-ft. tunnel used for calibrating measuring tapes; an antiknock engine with more than 30 quartz windows in the cylinder; an aeronautic-engine testing plant; the Hirschler apparatus for studying lubrication; various optical instruments and a diamond saw for cutting quartz in the optical laboratory; textile machinery; and metallurgical equipment.

Dr. Briggs was mentioned as one of the newest and most active members of the Bureau. He is assistant director of the Bureau and chief of the Aircraft Division. One of the problems upon which he and Dr. Dryden are working is the behavior of airplane-wing tips and propeller tips at high velocity. The outfit used includes a compressor and a nozzle which forces air over the part under test at a velocity of 600 ft. per sec. or more. Measurements are made under these conditions. The noise is deafening.

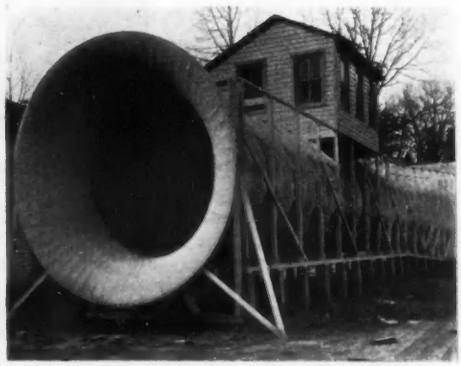
A 10-ft. wind-tunnel built out of doors is used for tests of various structures under wind conditions of 100 m.p.h. At the time Dr. Dickinson's pictures were taken, a derrick was mounted in the tunnel for wind-resistance study.

A uniform differing from those of the Army and Navy was shown in the experimental sound-chamber. It is a standard box or pillory in which the operator is concealed while making observations, so that the sound conditions in the room shall not be affected by the clothing he wears.

Dr. Dickinson refrained from claiming that the Bureau could enable the



INTEGRATING SPHERE FOR MEASURING LIGHT EMITTED FROM A LAMP



OUT-OF-DOOR TUNNEL AT BUREAU OF STANDARDS

citizen to keep his money any longer, but the experimental paper-mill which he showed has enabled the Bureau to improve the quality of the paper used in paper money, so that the new bills will wear two or three times as long as those that were made five years ago.

Casting a 100-In. Lens

One of the feats of the Bureau was the successful casting of a disc of glass, 100 in. in diameter and about 24 in. thick, for a telescope lens. Cooled by any ordinary method, such a piece of glass would break into a thousand fragments. It was cast and cooled in a firebrick pit, surrounded with electric heating-coils to control the temperature so that it could cool only a few degrees per day. The cooling of this disc occupied five or six months. The rate and manner of cooling were based upon an accurate study of the thermal conductivity of the glass and the stresses set up by various temperature differences.

Work done away from the buildings of the Bureau was represented by motion pictures showing methods of studying the stresses in the concrete work of the Arlington bridge across the Potomac River, now under construction, and of a burned five-story building in the City of Washington. The building was to be destroyed to make room for other structures, and the Bureau arranged to fill it with material and equipment representing various types of occupancy, including a large number of safes and an outfit of thermocouples for measuring the temperature at many different points.

At the conclusion of the pictures Dr. Dickinson answered several questions regarding the work of the Bureau.

Service Stations from Two Angles

Interesting Papers on Labor Economics and Management Presented at the New England Section

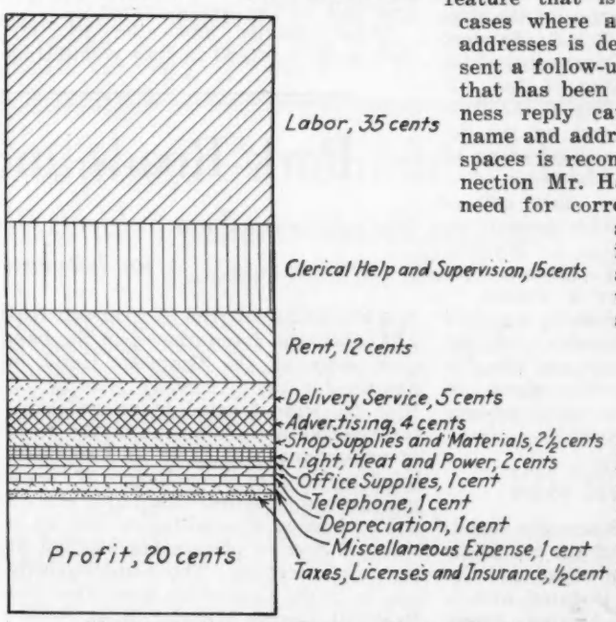
AT THE automotive service meeting of the New England Section, which was held in the Crystal Room of the Hotel Kenmore, Boston, on Feb. 13, the large number of members and their guests who attended listened to a discussion of service stations by two interesting speakers. The first paper was presented by L. T. Hanford, service representative of the United Motors Service, Inc., whose topic was Fundamental Economics of Automotive Service Labor; Knox T. Brown, general service manager of the Packard Motor Car Co. of Boston was the other speaker and discussed Service Management.

At a brief business meeting of the Section, which was held at the same time, the Section Nominating Committee was elected. The members of this Committee, the duty of which is to present nominations for Section officers to be elected at the May meeting, are G. L. Appleyard, Knox T. Brown, H. W. Johnson, A. E. Postal and Glenn S. Whitham.

Efficient Service Is Profitable

An efficient service department, said Mr. Hanford, is usually a profitable one and a profitable service station is usually an efficient one. This idea took root in the minds of many of the larger distributors and dealers some years ago, and in some cases they reorganized their service departments independently of the manufacturers and in a few instances despite the lack of appreciation from them. In 1928 the public paid for automotive maintenance and operation approximately $7,230,000,000. Of this sum labor cost $2,040,000,000 and replacement parts accounted for $1,360,000,000; in other words, for each dollar of service labor sold to the public, an additional 60 cents' worth of parts was sold.

A possible division of the service dollar, according to the speaker, was as follows: labor, 35 cents; clerical help and supervision, 15 cents; rent, 12 cents; light, heat and power, 2 cents; taxes, licenses and insurance, ½ cent; depreciation, 1 cent; shop supplies and materials, 2½ cents; office supplies, 1 cent; telephone, 1 cent; advertising, 4 cents; delivery service, 5 cents; miscellaneous expense, 1 cent; profit, 20 cents.


Labor, 35 cents
Clerical Help and Supervision, 15 cents
Rent, 12 cents
Delivery Service, 5 cents
Advertising, 4 cents
Shop Supplies and Materials, 2½ cents
Light, Heat and Power, 2 cents
Office Supplies, 1 cent
Telephone, 1 cent
Depreciation, 1 cent
Miscellaneous Expense, 1 cent
Taxes, Licenses and Insurance, ½ cent
Profit, 20 cents

HOW THE SERVICE DOLLAR MIGHT BE DIVIDED

While these figures would vary according to the location of the service station and a number of other items, they at least furnish a mark at which to aim.

In presenting the case of a hypothetical service-station, Mr. Hanford assumed that the labor sales would be $2,750, and in doing the work the mechanics would use $1,650 of parts and materials, thus giving a gross business of $4,400. The expense budget was $1,730. The profit on the parts and materials was assumed to be $330, and that on labor was $561, giving a total net profit of $891 on the productivity of five mechanics and two helpers.

Getting and Keeping Customers

Present customers are the best and most prolific form of sales promotion a service station can have, but care should be taken not to oversell them but rather to sell them well. In this connection the suggestion was made that service salesmen should be paid a commission on their sales.

Mr. Hanford discussed the various forms of advertising that a service station should use. Of these he considered a letter with a business reply envelope the best. Use of broadsides with illustrations designed to impress the recipient with the character of the workmanship and equipment of the station was also stressed. Letters of welcome to new customers were mentioned as a means of cultivating good-will and attention, the idea back of this method being that, unless a service station can make a friend out of a new-car purchaser during the warranty period, the subsequent maintenance work will go elsewhere.

Making sure that the mailing list is kept uptodate is another important feature that is often neglected. In cases where a check on names and addresses is desired or customers are sent a follow-up card regarding work that has been done, the use of business reply cards with the owner's name and address typed in the proper spaces is recommended. In this connection Mr. Hanford emphasized the need for correct spelling of names and the use of proper initials as a means of avoiding complaints on the part of customers and securing replies.

What Is a Service Manager?

Four characteristics make a successful service manager, said Mr. Brown, in his address. These are (*a*) a keen desire to serve, and a sympathetic interest in, the public; (*b*) organizing ability; (*c*) vision, including an open

mind to learn; and (*d*) ability to radiate mechanical knowledge. The ideal start for a service managership is as a mechanic who has risen from the ranks and has been farsighted enough to acquaint himself with the fundamentals that are so necessary to a manager. Another good start is a college education.

Some knowledge of accounting and the ability to read a profit and loss statement understandingly are essential for a service manager. He should also understand the proper way to handle customers and be a student of the science of shop management.

In managing the Packard service station at Boston, Mr. Brown receives a number of reports each month which show at a glance the volume of work done and into what classifications it falls. Among these are charts for job orders written; productive hours for productive and non-productive men and foremen; a productivity chart that shows when and where the high and low spots occur; idle-time report; expenditures for shop supplies; non-chargeable overtime; paint-job analysis; service-vehicle work; policy work on new and used cars; accessory sales and profits; commissions paid to service salesmen on accessory sales; report of stock on hand; and a record of complaints.

The March meeting of the Section will be held at the Massachusetts Institute of Technology and will include an inspection of the new automotive and aeronautic laboratory.

Meetings of O. S. U. Student Branch

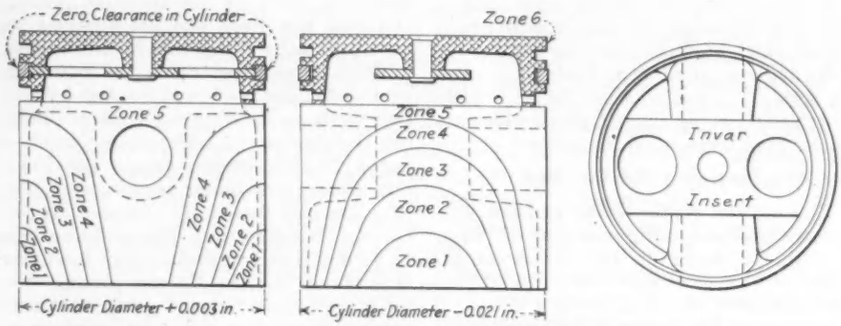
A REPORT on the Annual Meeting of the Society in Detroit was the feature of the first meeting of the winter quarter of the S.A.E. Student Branch of Ohio State University, which was held on the evening of Jan. 30. This was a dinner meeting at the Ohio Union, and C. P. Roberts, of the department of automotive engineering at the university, was the speaker.

Following the dinner, new officers were elected at a business session, as follows: President, Philip L. Knight; Vice-President, John W. Jordan; Secretary-Treasurer, Harry T. Buchs.

The second monthly meeting was held on Feb. 13, when members of the Branch met at and inspected the Columbus, Ohio, automobile show as guests of the Chamber of Commerce of the City of Columbus.

Piston Has Oval Skirt

GEORGE P. DORRIS was the speaker at the meeting of the St. Louis Section on Feb. 11. He expounded the Sterling piston, which is fitted with a piston-ring controlled by an Invar strut and has a continuous oval skirt that makes a progressively increasing contact with the cylinder as the temperature rises.



PISTON HAVING OVAL SKIRT AND CENTERED AT THE TOP BY INVAR STRUT

The axis of the oval of the piston is made very slightly longer in one direction than the cylinder diameter. The skirt is quite flexible, and a relatively small area of contact is established when the cold piston is pushed into the cylinder. As the piston becomes warmer in service, expansion causes contact in successive zones. As the contact increases, the cooling effect increases; until an equilibrium is established when all the heat received by the piston is transferred into the water-jacket. Rocking of the piston is prevented by the strut-controlled ring.

Short connecting-rods and pistons and full-length water-jackets are advocated by Mr. Dorris, who said that the improved cooling resulting from the long water-jacket is beneficial in controlling piston expansion. The maximum side-pressure on the piston, he said, occurs near the beginning of the stroke at a point where greater connecting-rod length is of little benefit. Shortening the rod reduces the reciprocating weight and reduces the weight and bulk of the whole engine.

Other details advocated by Mr. Dorris are a forged tubular connecting-rod, which makes the construction stiff in proportion to its weight, and the clamping of the piston-pin in the rod, which gives favorable lubricating conditions for the piston-pin, allows less chance for looseness than the floating pin and eliminates the piston-pin from the weight that is supported by the piston-pin bearing.

In the discussion that followed the presentation of his paper, Mr. Dorris said that the pistons and connecting-rods should be given consideration ahead of everything else; the engine should be built around them. He believes that extra expense in these parts is money well invested. The turned and drilled rod he believes to be less expensive to manufacture than a milled rod.

Mr. Dorris recommended that the cylinder-bore extend downward far enough so that the piston will project into the crankcase only about ⅛ in. at the bottom of the stroke. This will give almost the maximum provision for cooling the piston in the water-jacketed cylinder and prevent wearing a shoulder in the cylinder-bore. Making the piston without a horizontal slot provides a better path for the transfer of heat from the piston-head to the cylinder-wall.

Park Roads and Ignition Cable

Speakers on Two Subjects Give Northwest Section Members an Interesting Evening

MEMBERS of the Northwest Section who foregathered in the banquet room of the Gowman Hotel in Seattle for their monthly meeting on Feb. 15, were treated to an evening's informative entertainment in the form of extemporaneous talks on two unrelated topics. On the principle of "business before pleasure," they first elected a Nominating Committee to put up a slate of Section officers for election at the April meeting. Those unanimously elected to the Committee were Sherman Bushnell, George Webster, R. C. Pitzer, Byron Carr and George Hunsdorfer. Chairman Robert S. Taylor, who presided, held up four applications for memberships which were brought in by William Shadoff, of Everett, Wash., saying they were not the first four turned in by "Bill" and that he would appoint him an "outside" member of of the Section Membership Committee.

To promote better acquaintance among those at the meeting, C. C. Finn, who had charge of seating arrangements at the dinner that preceded the technical session, had small tables set up instead of one or two long tables; and at the opening of the session he read the

names of those present from the registration cards and introduced the members as they stood up. Mr. Finn also introduced the first speaker of the evening, Asabel Curtis, with whom he had been associated in the development of highways in all parts of the State of Washington, more specifically in the work of providing roads in Mount Rainier National Park. "Our mountain," he said, "which is only 65 miles away, is one of the most valuable assets of the State, because we can sell it over and over again and still have it."

Making Public Playgrounds Accessible

Mr. Curtis illustrated his talk with large panoramic photographs and maps showing the roads that have been built and those projected in Rainier Park, explaining their location and the topographic difficulties encountered. Much of the address dealt with the work of the Rainier National Park Advisory Board, which was organized years ago by 16 men from Tacoma and 16 from Seattle, for the purpose of formulating a common plan of development of the park. Mount Rainier was set aside as a National park in 1899, said Mr. Curtis, and the Advisory Board presented to the Department of the Interior five or six years ago a road-building program involving an estimated expenditure of $6,500,000. Up to the present, $2,380,000 has been spent and $8,150,000 more will be required to complete the road system.

The Advisory Board has now stopped asking for money for the Rainier National Park and swung into the great National program to make all of the 22 National parks more accessible as public playgrounds and has asked Congress for $50,000,000 for this purpose. As an indication of how the public appreciates this work, he said the year the Board began its work 8400 people visited Rainier Park and last year the number had increased to 128,000.

Although many private citizens worked a long time for the development of a National park system of roads, it was not until Secretary of the Interior Lane called Steven Mather into the National park work that it was possible to sell the idea to the railroads and the wealthy people of the United States. It was Mather who put the Rainier National Park on the map, and the people of Tennessee and North Carolina thought so well of it that the two States have raised and appropriated $5,000,000 to acquire land in the Smoky Mountains for a National park that will cost about $10,000,000.

The Federal Government is going to spend $11,000,000 in building a road system in Rainier Park and $5,000,000 for hotels, motorcoach lines, concessions, camp grounds and so forth.

Coping with Corona Effects

The second speaker of the evening, Ray E. Voorhees, representing the Packard Electric Co., gave interesting demonstrations of the corona effect in automotive ignition cable and narrated the difficulties the company has had to overcome in the last few years in producing cable that is satisfactory for use on high-compression engines.

After developing rubber-coated cable for its own use on Packard cars in the last years of the 19th century and later supplying other automobile manufacturers, the company experienced very little difficulty with this product for about 15 years, but in the last 4 or 5 years it has had to work night and day to keep up with changing conditions in the automotive industries.

The development of high-compression automobile and aircraft engines has set up the condition of corona, which played havoc with the ignition cables. The higher the compression in an engine is, the more voltage is developed in the coil. A few years ago the voltage used was about 6000 or 8000 volts; today 18,000 volts is common and the voltage sometimes runs as high as 22,000. Corona comes into the picture, remarked Mr. Voorhees, at 10,000 volts. It breaks up the atmosphere surrounding an electric conductor, liberating free oxygen or ozone, that attacks the protective coating on the outside. A purple glow and an obnoxious odor accompany the phenomenon.

Difficulties Finally Overcome

The only way that has been found to overcome the effects of corona is to seal the rubber-covered cable air-tight in a packing braid impregnated with multiple coats of lacquer. If the coating should be punctured with a pin or knife point, the corona would quickly drill a hole through to the copper core and short-circuit it. While sealing the cable air-tight against corona is a simple matter, it was not so easy to produce a material that would withstand other detrimental conditions, such as heat, oil, water and vibration. When a coating was perfected that would withstand heat in the summer, the lacquer cracked at 20 deg. below zero in the winter. And when that condition was overcome, it was found that the lacquer would not stand up against oil or water. However, the problem was finally solved.

The speaker then had the room darkened and gave a demonstration with an electric machine developing 13,500 volts and with rubber-coated cable and the latest corona-proof cable. Whereas the rubber-coated cable failed in a few minutes, Mr. Voorhees said that the lacquered cable on one post had not been changed in the course of 150 demonstrations.

Cable Used in Airplanes

In reply to one of the numerous questions asked in the discussion, Mr. Voorhees stated that many large airplane companies are using 10 times as much lacquered cable of the kind he showed as of Government-specified cable. The reason for the Government specification of varnished cambric around the copper core is that it weighs less than rubber insulation, but most airplanes have cable insulated with rubber varnish and two coverings of outside braid.

William C. Bramhall commented on the corona jumping around the manifold through which cable is run, and wanted to know if that is destructive of the cable and why the corona appears between the manifold and the engine. Filing the manifold clean helped the condition a great deal. Another member stated that the effect is not corona but high-tension static, and is produced even with brand-new corona-proof ignition cable; he thinks a great mistake is made in running cable through a conduit and that the distributor wire should be kept away from the other wires.

Chicago Automobile-Show Meeting

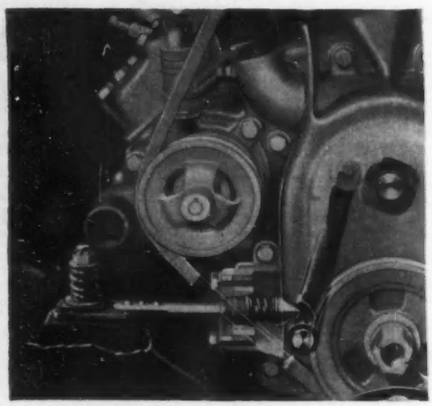
Two New Engines Described to Section Members—Horning Ponders on Past and Forecasts Future

IN ACCORDANCE with the precedent established last year, the Chicago Section held a dinner and meeting during the week of the Automobile Show. This was held in the south ballroom of the Stevens Hotel on the evening of Jan. 29 and was attended by 133 members and guests. Addresses were made by C. E. Summers, research engineer of the Oakland Motor Car Co.; Adam K. Stricker, Jr., of the Cadillac Motor Car Co. engineering department; and H. L. Horning, president and general manager of the Waukesha Motor Co. The first two described the new Oakland 8 and Cadillac 16-cylinder engines, while the topic of the last speaker was Modern Trends toward Like Cars of European Design, although what he actually said bore no relation to that title.

Three Years' Study Produced Oakland 8

A suggestion made by President Sloan, of the General Motors Corp., approximately three years ago, that the Oakland engineers look ahead from three to five years and try to meet the demand that would be made then, was

responsible, said Mr. Summers, for the new Oakland eight-cylinder engine. A sales analysis made at that time showed that, while eight-cylinder cars amounted to only about 2 per cent of the total sales in this Country, signs of an increase were apparent. Study of the situation and consideration of the trend in the motor-car industry toward more cylinders led to the decision to produce an eight-cylinder engine for the 1930 car.



OAKLAND-8 ENGINE SYNCHRONIZER

Used in Conjunction with Spring Mountings To Prevent Excessive Engine Movement Due to Road Shocks

Having made that decision, the question of V or in-line type came up for settlement. The piston-inertia torque is equally balanced in both types, and the consideration of the two types developed into a study of the economic problems involved. While for the manufacturers who have been building six-cylinder engines few new problems, aside from tooling, arise in changing to an in-line eight, a certain gain in body room is obtained for a chassis that formerly had a six-cylinder engine by installing a V-engine, because of a shorter crankshaft and engine-block; moreover, the water spaces and the valves are not crowded. A thorough analysis showed that, for the particular line and price class in which the eight-cylinder V-type engine was to be used, some practical and economic advantages accrued.

What the Synchronizer Does

Among the points mentioned by Mr. Summers as being somewhat unconventional in engine design were the use of a 180-deg. flat crankshaft, an angle cylinder-head, downdraft carburetion which was practically a necessity for that type of engine, a big bore and a short stroke, a combustion-chamber that permits high compression without detonation and a special mounting arrangement that eliminates virtually all vibration.

This mounting consists of a synchronizer that is used in connection with new spring-mountings for the front end of the engine. The latter permit the engine to move 0.01 in. laterally, an inherent feature of the V-type design embodying a single-plane crankshaft. The synchronizer, while following the normal sway or oscillation, prevents the engine from exceeding that movement as a result of road shocks. In addition to providing smoothness of operation at virtually all speeds, the use of the synchronizer effected considerable savings in crankshaft design and cost as well as in the balancing of all pistons and enabled a simple firing order to be used, thus eliminating some of the complications in the carburetion and manifolding.

Valve-Silencer Made Cadillac 16 Possible

Smooth performances was the foremost consideration with the Cadillac engineers, said Mr. Stricker, in the development of the 16-cylinder engine that made its initial appearance at this year's show in New York City. Although some design studies on 12-cylinder engines were made, nothing was actually built, and early in the development program the 16-cylinder engine was decided upon.

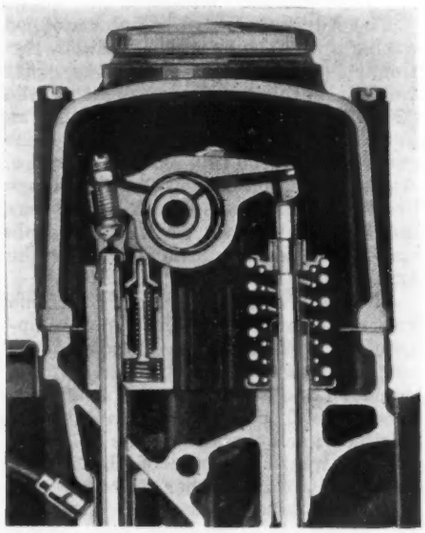
Exactly the same principle was used in this new engine as in the earlier eight-cylinder type, spacing the power impulses at even intervals, 45 deg. for the 16 cylinders and 90 deg. for the 8. Reducing the angle between the banks of cylinders to 45 deg., however, did not give sufficient room for the carbureters and manifold and the type of valve formerly used. This necessitated changing to overhead valves and the development of an automatic valve-silencer that really made this engine possible.

The silencer is a very simple device that consists merely of mounting the rocker-arm on the outside of an eccentric bushing, which raises and lowers the entire rocker-arm as it is turned around the rocker-arm shaft. A cam mounted on this bushing rests on top of a small piston, the two being kept in close contact by a spring under the piston, which turns the bushing, lowers the rocker-arm and takes up all clearance. When the valve is open, the valve-spring tends to force the bushing back because of the eccentric mounting. Oil under the piston restrains any motion of the bushing by a dashpot action. When the valve-stem expands, the pressure increases slowly and gradually and the oil in the small cylinder of the dashpot escapes into the clearance space of 0.0025 or 0.0030 in. between the cylinder and the piston, the latter sinking down and assuming a new position in the cylinder. The oil that is forced out of the cylinder escapes through four relief holes in the top of the dashpot piston. When the valve-stem contracts, the spring tends to raise the piston to its former position, thus creating a partial vacuum underneath the piston where the oil has been forced out. This opens a small check-valve inside the piston, allows the oil to escape and restores conditions to those existing before the action started. The parts move through a very small range and, as the movement is through oil, the wear is practically nil.

Other features of the Cadillac engine include a two-plane five-bearing crankshaft having the same arrangement and crank thrust as on the conventional straight-eight, a harmonic balancer, dual carburetion and a rather unusual cooling system in which the water for the left cylinder-block enters through a passage cast in the crankcase and is passed by a pipe to the center of the block.

Horning Reviews and Prophesies

In one of his characteristically humorous and informing addresses, Past-President Horning reviewed the developments of the last 10 years and pointed out some problems of the immediate future. One of the most outstanding problems was that of detonation, which was stated to be practically solved by the development of combustion-chambers that can use a compression ratio of 6 to 1 as compared with 4 to 1 about 10 years ago. Progress from now on will be more gradual until a ratio of 7 to 1 is reached, which is the point in the air-cycle efficiency at which an increase in compression fails to produce correspondingly better efficiency.



CADILLAC-16 ENGINE VALVE-SILENCER

The Rocker-Arm Is Mounted on an Eccentric Bushing and a Cam on the Arm Rests on a Dashpot Piston, So that All Clearance Is Taken Up

Another problem was the gradual increase in speeds that accompanied the change in compression ratios and resulted in more valve-spring breakage. Progress has been made in solving this problem at speeds of between 2000 and

3000 r.p.m., said Mr. Horning, but when the speeds are increased to between 3000 and 4000 r.p.m. the high forces involved in rapidly moving valves cause trouble.

Cooling the exhaust valve and its seat is believed by the speaker to be one of the most severe problems facing the engineers in the next decade. Allied with this heat-control question is that of keeping the oil temperature reasonably constant throughout the year.

Charging cylinders will become more troublesome in the next 10 years than it has been heretofore. While we know how to design many other parts of the engine, said Mr. Horning, we have absolutely forgotten how to secure easy flow. If engine power is to be increased, the manifold and the fuel passages in the cylinders must be designed to produce better cylinder-charging.

Will Make Advances in Lubrication

Lubrication along the cylinder-wall is more of a problem than in the bearings except in the very high-pressure bearings on the crankshaft. One of the greatest advances in the next decade will be a better understanding of piston and piston-wall lubrication, prophesied the speaker. Bearing surfaces will be a subject of intensive research. We are beginning to find out how to put a more effective film of lubrication on the bearing surfaces and how to make these surfaces function more efficiently, and Mr. Horning added that one of the greatest advances along this line would be the use of relatively smaller bearing surfaces without failure from overpressure or lack of lubrication.

What happens to the various engine mechanisms when under motion is perhaps the greatest problem that faces engineers in the next 10 years, said Mr. Horning, as we have no idea what is happening in the engine mechanisms when they are under high speed and varying stresses. The nature of a connecting-rod and its behavior under the intermediate and major periodicities of a crankshaft, and the distortion of a piston as it travels up and down in the cylinder, must be understood. The greatest advances, said the speaker, will be made in this field and in the study of synchronous vibration.

Eats, Music and Rubber

Cleveland Section Hears about Vibration Insulators, Compounding and Rubber Steering-Wheels

FOLLOWING a dinner interspersed with music and the distribution of favors provided by the American Hard Rubber Co., 67 members of the Cleveland Section listened to dissertations on rubber by a delegation from Akron, Ohio, at the Feb. 10 meeting in the ballroom of the Hotel Cleveland and then cross-examined the speakers.

Section Chairman W. E. England opened the technical program with the remark that the meeting should have been announced as sponsored by the Akron crowd and that, although the subject of the evening was rubber, tires were the only rubber thing that the gathering was not going to talk about, because they are so good these days that there is very little occasion to cuss or discuss them. He then turned the chair over to R. W. Brown, of the Firestone Tire & Rubber Co., who he said had secured the speakers and arranged the program.

Applications of Rubber Articulation

Rubber Articulation was the title of the first paper, which was presented by Robert F. Cowell, engineer of rubber shock-insulation with Mack Trucks, Inc. He told about some of the considerations that entered into the designing of the application of rubber to the motor-vehicle and illustrated his address with lantern slides of drawings of different shock-insulator devices, including spring shackles, engine supports, torque insulators, body-panel insulation, insulated seats and even rubber street paving.

Stock used for the shackles was developed by the rubber companies especially for the purpose after a great many trials before a compound was found that stands up well in service. The stock should have a minimum tensile-strength of 2000 lb. per sq. in., said Mr. Cowell, and an ultimate elongation of 450 per cent of its original length. Tests have shown that this stock will take a permanent set under a constant load of more than about 150 lb. per sq. in. The shock insulator was described as "a shock cushion which irons out the irregularities of the road and saves the chassis and body a great deal of grief." Also, the passenger is conscious of an easier and quieter ride.

"Shudder-proof insulation" is a term applied by the Mack experimental engineering division to a standardized line of rubber cushioning developed for industrial machinery. This insulation can be applied to stationary-engine supports, in motor-vehicles, airplanes and boats or wherever the transfer of vibration from a source to another part must be stopped.

The torque insulator is inserted in the driving line, as between the clutch and transmission, and consists of four generously proportioned rubber cushions assembled into metal cups mounted on two arms, one driving and the other driven. A form of torque insulator has recently been developed for attachment to the rear wheels of a vehicle, the cushions being inserted between cast housings on the axle shaft and on the wheel hub. This form effects a great saving of shock to the shafts, gears and engine of a dump truck working in excavations.

Squeaks, rattles and drumming are eliminated from bodies by inserting rubber molding in the turned edges of body panels and putting it under displacement by clamping. Use of this method speeds up body production, as panels and stampings do not need to be formed so accurately as for welded or riveted construction. The molding gives metal bodies the advantages of the semi-flexible Weymann body without sacrificing rapid production, according to Mr. Cowell.

Another recent development is a specially designed seat-frame that is shock-insulated with rubber under displacement. This seat has been demonstrated in service to afford the passenger exceptional comfort, absorbing not only road shocks but also engine vibrations.

Evaluating Insulator Tests

Frank D. Abbott, of the Firestone company, dealt with the tests applied to different rubber compounds in laboratory analysis to determine their suitability for the services to which they are intended to be put. The various tests, which were illustrated with slides of test apparatus and charts, include those for tensile strength, stresses at various elongations, hardness, resistance to aging, tear and cutting resistance, shear, adhesion, resistance to fatigue, deflectability under compression, impact, hysteresis properties and sound transmission. In the case of rubber vibration-insulators, it is highly desirable, said Mr. Abbott in conclusion, that the physical properties be evaluated only by tests simulating actual service conditions, particularly as regards frequencies and stressing.

Wants Engineers To Know Rubber

There seems to be a sort of haziness in the minds of a great many engineers as to the physical characteristics of rubber, said V. A. Cosler, of the B. F. Goodrich Co., who expressed the conviction that we have hardly scratched the surface of the extension of the use of rubber in industry. He believes that the only economical and rapid way of extending such use is by close cooperation between engineers in other industries and those in the rubber industry. The "hard-boiled" engineer knows all about metal alloys, babbitt metal and various other materials that can be bought in a large variety of combinations and will not buy steel unless he

knows its physical characteristics down to the last fraction of an ounce, but he is vague about rubber combinations. Blame for this condition was laid by Mr. Cosler upon the rubber companies for making a mystery of the subject of compounding. Back of this mystery is the chemist, who "is just smart enough to build up a nice alibi for himself when a given product does not meet the full tensile-strength specified."

Much of this mystery put into rubber by the compounder or rubber technician was taken out by Mr. Cosler in his description of what materials the compounder works with and how he puts them together. Vulcanization is the basis of all compounding, as the amount of heat to be applied to the mixture to vulcanize it is of prime importance and is the first factor to be considered. Within the last two years a very important ingredient known as antioxidant has come into use in the industry to prevent rapid oxidation. This has made the point of optimum cure of less importance than formerly, and it now is possible to either undercure or over-cure to a not too great extent and still get good aging properties.

Numerous samples of rubber having different properties were exhibited and slides were also shown to illustrate Mr. Cosler's talk. He said he would like to have engineers become familiar with the common characteristics obtainable in rubber by means of mixing so that they can describe the characteristics they want for a given service.

Rubber-Bushed Spring-Shackles

Experimental work in the developing of spring shackles with rubber inserts was narrated by H. S. Powell, of Powell Mufflers, of Utica, N. Y. The first of these rubber spring-shackles, designed with the object of silencing the shackles, were produced in 1923 or 1924 and have been in use ever since on a car that is still running, which Mr. Powell said speaks well for the rubber compound that was used. It was bumper rubber, which was inserted in a steel sleeve, after which a taper pilot was forced through the center. This worked well but was rather stiff because of the density of the rubber and did not improve the riding-qualities of the car.

Further experiments resulted in the use of a lighter rubber, a center sleeve having indentations around it, and enlarging the outer ends of the bushing so that it curves in toward the center. This type has proved successful. It can be oscillated at 30 deg., 100 times a minute, without showing any wear, according to Mr. Powell.

Rubber Steering-Wheels for Safety

A very different application of rubber to automobiles was described by H. T. Kraft, of the American Hard Rubber Co., who recounted the beginning and the development of hard-rubber steering-wheels as a safety measure. A man named Husted proposed the idea two years ago and finally induced Mr. Kraft's company to do some experimental work on it.

Although hard-rubber steering-wheels had been introduced 20 years ago, competition drove the price down to such an extent that the compound became of such inferior quality that the public did not want them. To avoid this condition, Mr. Kraft's company decided that it would never reduce the quality of the rubber compound but would try mechanical and other means to get low cost. After 1,500,000 wheels had been put into service, strong competition developed and a new type of wheel was decided upon by the American Hard Rubber Co.

Probably several hundred of this new type are in use today. It is a one-piece stamping consisting of a reinforced hub and tubular spokes and rim, and is coated with hard rubber of a high quality. The major difficulty that had to be overcome was to cause the rubber to adhere to the steel over the entire spider and to distribute the contraction of the rubber in such a way that during the cure the stress on the stock would be uniform throughout, since steel and rubber have considerably different ratios of expansion. To make sure that the wheels would withstand extreme temperature changes, tests were made at temperatures ranging from —50 to 130 deg. fahr. Absolutely clean materials and extreme care in handling are essential, said Mr. Kraft, to produce a rubber stock that will take and maintain an ebony luster and withstand exposure to the elements, perspiration, alkalies and rough usage.

Tests for Abrasion and Oil Effects

In the discussion, Mr. Mills, of the Gabriel Snubber Mfg. Co., asked Mr. Abbott if he has any standard accelerated abrasion test for rubber and an accelerator test for resistance to oil. Mr. Abbott's answer was that he knows of no well-accepted accelerated abrasion test, although some people are working on the problem and possibly within a year a fairly satisfactory machine will be developed. Neither is there a universally accepted accelerated method of testing the resistance of rubber to oils. Mr. Cosler added that the customary way of checking against the effect of oil is to measure some characteristic, such as tensile strength or cross-section, before and after immersion in oil.

Ferdinand Jehle, of the White Co., inquired if any flexible rubber hose is made that is really good for conveying oil up to a temperature of about 200 deg. fahr. Mr. Cosler's reply was not encouraging.

Mr. Abbott suggested that some sort of compression test might be valuable in evaluating rubber before and after oil absorption, to which Mr. Cosler responded that such a test is an indirect tensile-strength test and the size of the test specimen determines the distribution of the force causing distortion. He thinks a tear test is more indicative of the amount of deterioration due to oil absorption.

A. K. Brumbaugh, of the White Motor Co., was interested to know if there is any coating that can be put on tires to protect them from oil drippings while in storage, thus bringing tires into the meeting for the first time. There are plenty of such coatings, said Mr. Cosler, but they have different characteristics than rubber and soon crack, thereby localizing the action of the oil.

Another White man, W. S. Howard, pursuing the same line of thought, sought to know whether there are any greases that will not injure tire casings when the grease drips out of bearings that are supposed to retain it. Mr. Cosler's cryptic reply was, "Aquadate, or any of the water suspensions of graphite." He added that castor-oil is not highly deteriorating; the mineral oils in general are the most deteriorating in their action.

Oil-Round Lively Meeting

Speakers on Fuels Bombarded with Queries by Southern California Section Members

WITH a speaker from the Associated Oil Co., one from the Standard Oil Co., and another from the Ethyl Gasoline Corp., the February meeting of the Southern California Section was an OIL-round success.

One of the liveliest spots on the program occurred after the principal talks were finished when rank and file engineers bombarded the fuel specialists with pointed questions.

At the finish of Frank Elliott's very illuminating demonstration of the knocking propensities of Texas gasoline, C. E. Emmons, of the Texas Co., rose to inquire if Texas was referred to geographically or corporationally. The Ethyl expert hastened to reply that he referred to nature's product, not Texaco.

E. Favary, of the Moreland Motor Truck Co., challenged the Standard Oil representative on the subject of vapor lock. The question was whether

H. T. Ramsay advocated the carrying of an auxiliary tank of less volatile fuel in the car so that when a long grade was encountered on a hot day and gas-lock set in the motorist could switch from the regular tank to the spare tank. Mr. Ramsay informed the assemblage that no such cumbersome precaution was necessary, as oil-company chemists study temperatures constantly, producing fuel having the right volatility for every season.

John Wiggers, also of Moreland, thereupon "asked to know" why Standard made so much ado about winter gasoline and then crept advertising-LESS into the warm season without a single word about summer gasoline. Mr. Ramsay met the query in a deft way, saying that, in his opinion, the advertising of winter gasoline is a psychological move based on the assumption that touring diminishes in the winter and needs stimulation, whereas, when spring arrives with its own inducements, no argument on the part of a commercial organization is necessary to urge motorists to take to the throttle.

Gasoline Production and Vapor Lock

The opening speech of the meeting was delivered by J. M. Evans, of the Associated Oil Co., whose discourse was highly interesting to the automotive group, for it dealt with the progress of distilling and refining gasoline. Mr. Evans covered his subject quite thoroughly, beginning with the first crude equipment and step by step bringing his listeners down to the present highly efficient method of separating gasoline from kerosene and stove oil.

Harold T. Ramsay, of the Standard Oil Co. followed with a talk on the cause, effect and cure of vapor lock. He gave the craft some highly usable information on this important subject and offered some sound advice on the location of elements in the supply line with relation to the engine and its exhaust.

A Knocking Demonstration

The closing event on the program was a talk on Ethyl, by Frank Elliott, who certainly should know a great deal about motor fuel for he has been burning up gasoline, roads and miles for many a year in the racing profession. To illustrate his contentions, he brought along a gasoline engine and a "detonation-exposer," the latter being a meter panel having a series of electric lights mounted on it. The speaker explained that the brilliance of the lamps would increase in accordance with the severity of detonation. He proceeded to feed the engine with gasoline of various types so that the assemblage might observe the knocking tendencies visually as well as audibly; also the lack of knocking when Ethyl fluid was added. That this demonstration was of intense interest to the engineers was evidenced by the flood of questions that were directed toward Mr. Elliott at the conclusion of his discourse.

Mr. Gustus, of the General Electric Co., inquired if Ethyl is injurious to valves. The answer was "No more than ordinary fuel."

Mr. Campbell, of the Kinner Airplane & Motor Co., wanted to know if Ethyl attacks some metals more than others, as for instance certain aluminum alloys. The reply was "Yes."

J. F. Dickson, of the Dickson Co., was curious to know if the spark could be advanced with Ethyl in the tank. The answer was in the affirmative.

Mr. Powelson, of the Los Angeles County Engineering Department, asked about Ethyl's harmful effect on the mechanism of the carbureter or valves. Mr. Elliott answered that it has none and added that the white deposit found on metal parts, and sometimes mistaken for burn, is lead bromide, which is harmless and easy to remove.

Mr. White, of Standard Oil, inquired as to Ethyl's fuel value. The response was that it is not a fuel but is strictly a detonation eliminator.

Choking Can't Stop Vapor Lock

Mr. Ramsay was also bombarded with interrogations. Mr. Moore, of the Electric Equipment Co., wanted to know if choking the engine when it seemed to be weakening would thwart vapor lock. The answer was "No, choke pulling has but a momentary effect; if the lock is coming, it will manifest itself whether the choke is used or not."

W. G. Careins, of the Nash Motors Co., of Kenosha, Wis., and a member of the Milwaukee Section, inquired if the proximity of the sea-level and desert areas in Southern California encourages gas-lock. The answer was "No, manufacturers take into consideration this condition in manufacturing gasoline for use in this section."

The speakers used the blackboard freely to illustrate their explanations. There was a dominant strain of "anti-knock" throughout the three speeches, which was quite remarkable, considering the keen competition represented by the speakers.

Members to the number of 147 were present for dinner, and 30 more came in later. Chairman Fairbanks announced the forthcoming social event, a dinner dance, at the Alexandria Hotel, the date being March 1. The Section members were invited to attend en masse as guests of the Southern California Automobile Dealers Association, whose annual automobile show was to be held in Los Angeles from Feb. 22 to March 2. E. Favary, Fred Patton and J. J. Carnavan were appointed as judges to award prizes for the most venerable vehicles exhibited at the old-car display, which was to be a feature of the show. Chairman Fairbanks, looking over the committee trio, ventured that they appeared to be just the type to pick antiques.

The meeting closed promptly at 10 o'clock. To the assembled engineers it was packed with valuable details and many interesting sidelights. To an outsider, it left the impression that, in spite of all the molecules, atoms and fractions, it is still necessary to turn on the ignition, step on the starter, and away she goes.

BUD LANDIS.

Body Cleaning and Finishing

Cleansers, Finishing Materials and Processes Occupy Attention of Quaker City Gathering

THE Pennsylvania Section probably will not be heard from much longer. Not that it is disintegrating; rather, it is differentiating. Since a Section now exists in Pittsburgh, it has been thought advisable to change the name of the older Section to the Philadelphia Section. A motion that such a change should be recommended to the Council of the Society was passed, as suggested by the Section officers, at the Feb. 12 meeting of the Section at the rooms of the Philadelphia Automobile Trade Association. About 75 members and guests attended the meeting, which was preceded by a dinner and entertainment à la Cap Risley.

Cosmetics and Other Body Finishes was the announced subject of the meeting, and F. P. Spruance served as the slave with the olive oil when he presented his paper on the proper preparation of sheet metal for painting. Applying primarily to metal automobile bodies, the same methods can be used wherever sheet steel is fabricated.

Rust Must Be Conquered

Rust is the great enemy of metal finish. Pickling with sulphuric acid and cleaning with muriatic acid leave a tendency to breed rust, in spite of washing and oiling for shipment and storage. Soldering acids and pastes also are active rusters. Complete removal or destruction of the acid is necessary to prevent rusting, according to Mr. Spruance, since the salts resulting from neutralization are rust producers. Everything in the nature of oil and

graphite must be removed also, and alkalis are objectionable.

Sand-blasting is costly and has been found ineffective in preventing rust, although it does remove existing rust. In 1914, George D. Feidt mixed phosphoric acid and alcohol to produce a cleansing medium, which is now marketed by the American Chemical Patent Co., with which Mr. Spruance is connected. Phosphoric acid is as effective as muriatic acid in cleaning, the products of the reaction are beneficial rather than detrimental, and the material is not too expensive for commercial use.

Methods and processes, both wet and dry, for the application of this material were described in detail. Mr. Spruance's final word was a recommendation that the cleaning should be done immediately after any soldering, before rust has been formed.

Body-finishing materials and processes were described by George F. Farnsworth, director of the Budd Laboratories in Detroit, who said that the finishing coats of an automobile body are divided into three major groups: primer, filler or surfacer, and color finishing-coats.

Oil and Synthetic Bases Used

The original conception of a pyroxylin body-finish was that it should be composed entirely of lacquer, but most production finishes for cars now include oil coats for at least the primer. One reason given for this is that pyroxylin primers and fillers dry only by evaporation and therefore shrink in drying more than do the oil coats, which dry by oxidation also. Underlying defects therefore are more likely to show up with age, unless an exceptionally long time is allowed for drying before the sanding operation.

Production finishing requires the use of drying ovens, for the oil coats, which cannot well be provided in the refinishing shop. Good refinishing jobs can be done, Mr. Farnsworth said, by sanding the original finish and applying pyroxylin coats.

Many of the disadvantages of both the pyroxylin and baked oil-base surfacers have been overcome by the so-called one-bake or synthetic surfacer, comprising a varnish manufactured from synthetic resins and China wood-oil. The advantage of this method is that two or three heavy coats can be applied in rapid succession and baked in one operation. Development of materials and machines will soon make hand striping and tape or metal shields unnecessary.

A lively discussion followed the presentation of the two papers. One of the questions asked had to do with the use of sulphuric-acid solution in cleaning, and it was answered by both Mr. Spruance and James F. Gravell, president of the American Chemical Paint Co., who disapproved of its use. Mr. Gravell said that sulphuric acid, applied to steel, produces iron sulphate, which oxidizes to rust and liberates sulphuric acid which attacks the steel again. Several other acids produce similar results. Phosphoric acid is a little slower but is free from bad after-results.

Finishing Metal That Is Not Smooth

Before adjourning the meeting, Walter Graf, who served as Chairman, called upon Joseph Meadowcroft, welding engineer and assistant works manager of the E. G. Budd Mfg. Co. Mr. Meadowcroft said that, just when the steel mills have improved automobile body sheets to secure high luster, finishing processes have been developed to make possible the use of steel having an elongation of about 30 per cent, from which the entire side of an automobile body can be formed in one piece, with an outside finish that would be the despair of an old-time painter. The outside finish of the steel must be sacrificed to secure the drawing quality, necessitating additional filling operations in the lacquering process.

Straightening high and low spots in the sheets by hammering, grinding and "dinging" has been an important item of cost. Mr. Meadowcroft said that this can be avoided by designing the dies to form stampings without high and low spots; scratches and other small imperfections can be covered in the finishing.

Diesel Engines and Aviation

Survey of Automotive Prospects by Roswell Ward Featured Large Meeting of Buffalo Section

DIESEL engines, particularly their development for aircraft, was the subject of the Feb. 4 meeting of the Buffalo Section at the Hotel Statler, and the speaker was Roswell Ward, managing editor of *Motorship*. The attendance was said to be 265, adding one more large meeting to the record of the present Governing Board of the Section.

Mr. Ward believes that popular interest in Diesel engines for aviation has outrun the actual development. He pointed out that little development has occurred in this Country on Diesel engines for tractors, trucks and motor-coaches, so that many engineers have a long jump to take from the stationary or the marine engine to the aviation engine. The greater European development of light Diesel engines can be credited to both the fuel situation and the fact that Germany was the birthplace of the idea.

The illustrations of Mr. Ward's paper began with a picture of Dr. Rudolph Diesel, who might be described as the only spark-plug the Diesel engine ever had.

Other pictures and descriptions followed the development of Diesel engines for marine service, logging draglines and contractors' machinery. Mr. Ward said that about one-half of the power shovels made by one of the leading American manufacturers of such equipment are now powered with Diesel engines.

Diesel Engines on Wheels

A short parade of Diesel-engined trucks followed, nearly all of European manufacture. Mention was made of the motorcoach that is being operated by the Public Service Co. of New Jersey, powered with a Mercedes-Benz engine and having electric transmission. Mr. Ward reported two difficulties with this coach, the first being that so many engineers ride in it that little room is left for regular passengers and the second that the operators did not like it at first because the acceleration of the engine is less than that of the engines to which they are accustomed. This vehicle is being used in city service, and Mr. Ward questions if it would not be more satisfactory in suburban service.

The recent trip of C. L. Cummins from Indiana to New York City was represented by a photograph of the Diesel-engined car that he drove. Mr. Cummins' attempt was pronounced a success by Mr. Ward, whether considered as a technical development or as an advertising stunt. The car is a converted Packard, weighing approximately 6000 lb. It has an axle ratio of 2½ to 1, because the engine operates at only 1000 r.p.m.; therefore Mr. Ward said that the car is a little slow in getting under way in traffic but pulls well on hills and over railroad crossings. The engine is started by relieving the compression on all four cylinders and cranking it with a 24-volt motor-generator. When the compression reliefs are closed and the fuel supplied, the engine starts.

Diesel Engines in the Air

Aviation development was represented by Mr. Ward first by an engine projected by the late General G. Guidoni, of the Royal Italian Airports, and a Maybach engine designed primarily for Zeppelins. The Italian engine uses a turbo compressor for supercharging. The Maybach engine

uses air injection and weighs about 18 lb. per hp. This weight and the adoption of gaseous fuel for the dirigibles were cited as the reasons for this engine never having been used for the aviation work for which it was primarily designed.

The Junkers engine is considered by Mr. Ward to be the most successful aeronautic Diesel engine yet produced, as it has seen much more actual flying service than the Packard engine. The development of this was begun as a war-time diversion, and the engine has since had the benefit of development in motor-truck service. The initial flight test was made on Dr. Junkers' seventieth birthday, Feb. 4, 1929. In its present form it has six cylinders with opposed pistons and two crankshafts. The crankshafts rotate at 1600 r.p.m. and are connected by gearing at the front. The propeller operates from an idler gear at 1120 r.p.m. The normal output of the engine is 600 hp., and the peak output is 700 hp. Scavenging air is supplied by turbo compressors, and the power is sustained up to 10,000-ft. altitude. The engine weighs 2.52 lb. per hp., and the fuel consumption is 0.39 lb. per b.hp.

Photographs of the Packard Diesel engine were shown also, but Mr. Ward said that no recent information is available and the development of the engine evidently is not yet completed.

Cost and Application

Cost was one of the subjects considered in the discussion. Aeronautic engines were said to range in cost from $15 to $20 per horsepower and ordinary Diesel engines to cost $50 per horsepower, and light Diesel engines much more. Among the reasons advanced for the high cost was the relatively slow speed.

Metering the fuel was said to be a very simple problem in the larger slow-speed Diesel engine. One powerplant was reported to have seven Diesel engines, with a load factor of 98 per cent of the rated power of the engines. All these engines are in operation for 98.8 per cent of the time, cleaning and normal maintenance occupying the rest of the time. None of the engines has had a forced shut-down during the three years of operating this plant.

William R. Gordon, of the Pierce-Arrow Motor Car Co., reported that Col. J. G. Vincent, of the Packard Motor Car Co., gave out a statement, when the company was besieged for information, that the application of the Diesel engine for automobiles would be limited because the high compression would be objectionable in idling, tremendous flywheel effect would be required, and the exhaust gas would be offensive. The opinion was expressed that an objectionable exhaust is not an unavoidable characteristic of the type.

Cooling Problems the Northern California Section Subject

HEAT transfer was the subject of the Northern California Section meeting at the Engineers' Club in San Francisco on Feb. 13. During the dinner service, Chairman H. L. Hirschler tapped on his glass with a fork and announced that the musical note sounded the exact hour for the Chairman of the Reception Committee to introduce new members; whereupon Sidney B. Shaw performed this office.

Carl J. Vogt, one of the new members and instructor in mechanical engineering at the University of California, laid in the groundwork of the subject by presenting the fundamentals of heat transfer and engine cooling. He made blackboard sketches showing the temperature drop at the oil films and through the metal of a water-jacket and emphasized the importance of turbulence in the water-jacket. He also discussed air-cooling, steam-cooling and chemical cooling as well as conventional water-cooling.

Heat Transfer Through Tubes

Heat Transfer through Tubes was the more specific subject treated by Fred W. Dittus, of the engineering department of the Standard Oil Co. of California. Over-all transfer factors only, he said, have been considered until recently in connection with heat transfer such as occurs in a radiator or other heat-transfer units. Inconsistencies in this factor made correlation of results impossible until Walter Louis McAdams showed that it was necessary to break up the total resistance into the resistance offered to heat-flow through the tube wall itself and the resistances at the two sides.

McAdams' equations, and modifications of it, gave greatly improved results, but some discrepancies were still found. In 1928, these were shown by Morris and Whitman, of the Standard Oil Co. of Indiana, to need an additional factor depending on the specific heat. The various formulas were written on the blackboard and explained by Mr. Dittus. He also explained that one of the chief difficulties with thermosiphon circulation is that the flow is viscous or non-turbulent, in that only the heated part of the cooling fluid remains in contact with the cooling surface as it circulates. This has been demonstrated by tests at the University of California.

Some of the data on heat transfer have been obtained from experiments with heated platinum wires. The wires have been calibrated for determining the velocity of air through a wind-tunnel, by measuring the amount of heat taken away from the electrically heated wire by the air, and the results of this work are available for other problems. Mr. Dittus emphasized the fact that heat transfer requires energy; so it is not surprising that turbulence, caused by forced circulation of the fluids, should increase the transfer.

Painting Radiator Aids Cooling

A discusser of these papers asked what would be the effect of painting the cooling surface of a radiator. He thought that coating with lacquer would tend to retard the radiation of heat. Mr. Vogt reported that tests had shown the dissipation of heat from the aluminum fins of an air-cooled engine had been increased 15 to 20 per cent by coating with lampblack, and said that black paint would increase the heat dissipation in a radiator.

The 40 members and guests present restrained any impulse they may have had to cheer when Chairman Hirschler announced that a decision of the Council of the parent Society was unfavorable to participation by the Section in further air-race meets. In spite of the wonderful success of events of the sort in which the Section has participated, this activity is felt to be a function of the National Aeronautical Association rather than of the Society of Automotive Engineers.

Recent Wichita Meetings

FUTURE possibilities of the liquid-cooled engine, fuels and lubricants and gliders were the subjects discussed at two recent meetings of the Wichita Section. At the meeting on Dec. 12, 1929, Rex B. Beisel, vice-president and chief engineer of the Spartan Aircraft Co., of Tulsa, Okla., presented a paper on Future Possibilities of the Liquid-Cooled Aircraft-Engine. The meeting was attended by approximately 50 members and guests, many of whom participated in the discussion that followed the presentation of the paper. Among the subjects covered in the discussion were different types of engine and propeller, cowling and spark-plugs.

Two papers were presented at the Jan. 16 meeting. The first, which was by D. C. K. Francis, oil technologist of the Skelly Oil Co., of Tulsa, was entitled, The Quality of Aircraft Fuels and Lubricants. The various properties of gasoline were described briefly and the tests employed to determine these outlined. The effect of faulty lubrication and poor quality of lubricants on the life and performance of aircraft powerplants was also discussed. The other paper, by Eldon W. Cessna, of the Cessna Aircraft Co., of Wichita, Kan., dealt with gliding. The development of this means of locomotion was described briefly, followed by a discussion of the design and construction of gliders. Mention of the records made in the field of soaring was made by Mr. Cessna, who said that the ultimate goal of soaring flight is dynamic soaring, which has never been accomplished by man.

Personal Notes of the Members

Conant Forms Own Organization

W. H. Conant, who has been chief of industrial operations for the J. G. White Management Corp., has taken over that corporation's industrial management business under the style of W. H. Conant Organization, 33 Liberty Street, New York City.

Virtually ever since completing his education, Mr. Conant has worked in various branches of the automotive field, which he entered in 1904. He was manager of the vehicle department and subsequently of the industrial division of the Gould Storage Battery Co., of New York City. He was general manager of the Pittsburgh Motor Vehicle Co., subsequently the Ward Motor Vehicle Co., and later president of the Washington Motor Vehicle Co. Still later he became president of the Prismolite Co. and of the Hardware Products Co., of Columbus and Cleveland, Ohio. In 1923 he went into professional management work and soon joined the J. G. White Management Corp., of New York City, assistant to the industrial division manager, later becoming industrial supervisor of that organization. Among his present and past professional business-management connections are: vice-president of the Temple Malleable & Steel Corp., general manager of the Panhard Oil Corp., president of the Hans Heinrichs Chemical Corp., vice-president of the New York Lubricating Oil Co., vice-president of the Carlstadt Holding Corp. and others.

W. H. CONANT

A paper on Storage Batteries by Mr. Conant, who became a Member of the Society in March, 1911, appeared in the BULLETIN for December, 1913, p. 143, and in TRANSACTIONS for 1914, part 1, p. 144. This has been referred to in a pamphlet of the New York Public Library as containing a good glossary of storage-battery nomenclature. Another paper entitled, Notes on Automotive Storage-Battery Practice, appeared in THE JOURNAL for August, 1917, beginning on p. 159. Articles of his on electric-vehicle design also appeared in trade papers in 1912.

For some years Mr. Conant was active in Society matters, serving on the following committees: Subcommittee on Recommended Standard Instructions for Use and Care of Storage-Batteries in Connection with Electric Starting and Lighting, 1913; the aforementioned Committee, the Electric-Vehicle Division of the Standards Committee, and the Standards Exchange Division, 1914; Electric-Vehicle and Electrical Equipment Division of the Standards Committee, 1915 and 1916; and the Starting-Battery Division, 1917. During 1915 he served as Secretary of the Detroit Section of the Society and Treasurer of the Society's Meetings Committee. In 1928 he was elected Secretary of the Metropolitan Section. He edited the first Section publication of the Society in Detroit in 1915, calling it the *Junior Bulletin*.

Hudson Joins New England Council

After eight years' work in the Division of Simplified Practice, of the United States Department of Commerce, Ray M. Hudson has resigned from the Government service to become manager of the industrial department of the New England Council. The career of Mr. Hudson, who is widely known as an expert on the elimination of waste in industry, is of more than ordinary interest, illustrating the development of an engineer in dhose work practical and theoretical activities are well balanced. A Personal Note giving extensive details of Mr. Hudson's career appeared on p. 16 of the January, 1928, issue of the S.A.E. JOURNAL.

Following his promotion by Mr. Hoover, then Secretary of Commerce, to the post of assistant director for commercial standards in the Bureau of Standards in 1927, Mr. Hudson supervised not only the Division of Simplified Practice but also the Bureau's divisions of Trade Standards, Specifications, and Building and Housing. He was responsible for the development of the Bureau's *Commercial Standards Monthly*, and prepared the section on simplification and standardization in Management's Handbook and a similar section for two successive editions of the Encyclopedia Britannica.

Mr. Hudson was elected a Member of the Society in October, 1923, and joined the Washington Section in 1925. At the November, 1927, Detroit Section Meeting, he gave a paper, Simplification an Aid to Industrial Self-Preservation, as part of the Symposium on Tire-Size Simplification, which was published in the S.A.E. JOURNAL for February, 1928, p. 228.

He is also a member of the Taylor Society and has been an active member of the Committee on Uniform Traffic Regulations of the Hoover Street and Highway Safety Conference, the National Distribution Conference Committee, the American Engineering Council's Committee on Research, the Society of Industrial Engineer's Committee on Waste Elimination, the National Research Council's Committee on Industrial Illumination, the National Committee on Wood Utilization, and others. For two years he was secretary of the National Management Week Committee, and in this capacity directed Management Week meetings in nearly 100 cities.

RAY M. HUDSON

Shepard with Stewart-Warner

E. H. Shepard, who recently resigned his position of chief engineer of the Holley Carburetor Co., of Detroit, has joined the Stewart Warner Corp. and is to handle sales to motor-car manufacturers in the carbureter division. He will have his headquarters in Chicago.

Having entered the automotive field at the dawn of this century, Mr. Shepard became connected in 1910 with the Stromberg Motor Devices Co., in New York City, as road engineer. Three years later he was transferred to the company's Detroit branch and assumed its management in 1918. In 1924 he became sales manager of the Holley

E. H. SHEPARD

Carburetor Co., and later its chief engineer. He accepted the position of sales manager for the Oil Automatic Heating Corp., of Detroit, in 1925, and during the following two years acted as sales manager of the equipment division of the Beneke Mfg. Co. In 1928 he returned to the Holley organization.

Mr. Shepard has been a Member of the Society since February, 1912. He joined the Detroit Section in 1920. His paper on Downdraft Carburetion was read at the 1930 Annual Meeting and published in the S.A.E. JOURNAL for February, 1930, beginning on p. 153.

Hyde a Trade Association Secretary

The position of executive secretary of the Indianapolis Automobile Trade Association has been accepted by Harlow Hyde, Secretary of the Indiana Section of the Society.

Although an Associate Member of the Society only since January, 1928, Mr. Hyde's connection with the automotive field covers a period of more than 20 years. He filled the post of advertising manager with several important firms from 1908 to 1928, being connected in turn with the Bosch Magneto Co., of New York City; the Stevens-Duryea Co., of Springfield, Mass.; the Empire Automobile Co., the Nordyke & Marmon Co. and the Stutz Motor Car Co. of America, all three of Indianapolis. Since the latter date, he has been in the independent field as an advertising and sales-promotion consultant at Indianapolis.

Dunham Engaged in Consulting Engineering

George W. Dunham, who for the last three years was vice-president of the Whirldry Corp., of New Haven, Conn., has opened offices as a consulting engineer at 535 Fifth Avenue, New York City.

After completing his education, Mr. Dunham became connected with the Olds Motor Works and rose to the position of chief engineer. When the Hudson Motor Co. was organized in 1909, he was one of the incorporators and took charge of engineering and production. The following year when the Hudson and Chalmers companies were organized, he became asociated with the Chalmers Motor Co. as vice-president and consulting engineer. In 1915 he opened offices in Detroit as consulting engineer, retaining the Chalmers connection, and was successful in building up a practice of very attractive proportions. During the World War he served as civilian member of the Committee for the Motorization of Field Artillery and was prominent in other military affairs. In 1921 he became associated with the Savage Arms Corp., specializing in pressed-steel and electrical appliances. Three years later he organized and was elected president and general manager of the George W. Dunham Corp., of Utica, N. Y., which was organized for the manufacture of household electrical appliances. This company later was reorganized as the Whirldry Corp. and moved to New Haven.

Mr. Dunham has been a Member of the Society since its early days, having been admitted in June 1908, and has been very active in its affairs. He served on the Aluminum and Copper-Alloys Division of the Standards Committee from 1910 to 1914. In 1917 he was President of the Society, and a Councilor the following year. Since then he has served on various divisions of the Standards Committee, as follows: Motorcycle Division, 1918 to 1920; Axle and Wheels Division and Ball and Roller-Bearings Division, 1922 and 1923. He was also a member of the Ordnance Advisory Committee from 1921 to 1923.

Mr. Dunham is the author of the following papers which have appeared

G. W. DUNHAM

in the publications of the Society: Standardization of Drawings, published in THE BULLETIN, August, 1912, p. 276, and December, 1912, p. 147; and TRANSACTIONS, 1913, part 1, p. 39; Standardization Work of the S.A.E., published in THE BULLETIN, March, 1917, p. 632; Future of the Farm Tractor Industry, published in THE JOURNAL, July, 1917, p. 98; S.A.E. Standardization, published in THE JOURNAL, December, 1921; Automotive Engineering in the War, published in THE JOURNAL, October, 1917; Artillery Motorization Related to Caterpillar Traction, published in THE JOURNAL, March, 1920, and also in TRANSACTIONS for 1920, part 1.

Maurice Botnick has recently become associated with the Silent Hoist Co., of Brooklyn, N. Y. Previously he was sales engineer with the material-handling division of Yale & Towne, Inc., in New York City.

Theodore A. Brewster has been employed as a full-size-body draftsman by the Hayes Body Co. of Grand Rapids, Mich. He was formerly employed in a similar capacity by the Pierce-Arrow Motor Car Corp. of Buffalo.

H. Fletcher Brown, formerly field manager for the Yellow Cab Airways, Inc., of Des Moines, Iowa, has accepted a position with the Travel Air Co. of Wichita, Kan.

B. C. Cleveland, who was formerly manager of the metallurgical department of Bell & Gosset Co. of Chicago, is now connected with the Lindberg Steel Treating Co. of Chicago.

L. C. Conradi became a metallurgist for the Lycoming Mfg. Co. of Williamsport, Pa., early in February. Previous

(*Continued on p. 40*)

Applicants Qualified

The following applicants have qualified for admission to the Society between Jan. 10 and Feb. 10, 1930. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (S M) Service Member; (F M) Foreign Member.

ADAMS, A. S. (M) technical assistant, Chevrolet Motor Car Co., *Detroit;* (mail) 9303 McQuade Avenue.

ADAMS, G. CARL (M) treasurer, engineer, Curtiss Aerocar Co. of Florida, Opalocka, Fla.; (mail) *County Club Estates, Fla.*

BACH, A. W. (J) assistant engineer, carbureter department, engineering department, International Harvester Co., Tractor Works, 2600 West 31st Boulevard, *Chicago;* (mail) 9040 Bishop.

BAITS, STUART G. (M) chief engineer, Hudson Motor Car Co., Detroit; (mail) 1410 Yorkshire Drive, *Grosse Pointe Park, Mich.*

BALINT, JULIUS J. (M) body engineer, Fisher Body Corp., *Detroit;* (mail) 12294 Washburn Avenue.

BATTENFELD, C. F. (A) president, general manager, C. F. Battenfeld Oil Co., 1340 Oakman Boulevard, *Detroit.*

BAUMANN, MILTON C. (M) chief engineer, Butler Aircraft Corp., 834 Richards Road, Kansas City Airport, *Kansas City, Mo.*

BOSS, KENNETH A. (M) lubrication engineer, Willhelm Oil Co., 2361 Hampden Avenue, *St. Paul.*

BOYSEN, HERMANN (M) layout draftsman, American LaFrance & Foamite Co., Inc., *Elmira, N. Y.*

BREESE, VANCE (J) president, Breese Aircraft Corp., *Portland, Ore.;* (mail) 555 Raleigh Street.

BROWN, HORACE W. (A) owner, 40 Middlesex Street, *Haverhill, Mass.*

BURCH, FRANK M. (A) quality manager, H. H. Franklin Mfg. Co., *Syracuse.*

BURNS, W. RUSSELL (A) president, treasurer, W. R. Burns Co., 45 Broadway, *Providence, R. I.*

CARRINGTON, JAMES E. (A) salesman, tool engineer, Carboloy Co., *Detroit;* (mail) 329 Holbrook Avenue.

CASLER, R. H. (J) automotive division, commercial department, Westinghouse Air Brake Co., 150 Broadway, *New York City.*

CESSNA, ELDON W. (J) assistant chief engineer, Cessna Aircraft Co., *Wichita, Kan.;* (mail) 237 South Terrace Drive.

CHUDAKOV, EUGENE A. (F M) chairman, scientific council, Scientific Automotive Institute of the U.S.S.R., *Moscow, U.S.S.R.;* (mail) Maschkov Pez. N 1.

CULLOM, KENNETH S. (M) test engineer, aircraft engines, E. W. Bliss Co., *Brooklyn, N. Y.;* (mail) Ninth Street Y.M.C.A.

CUNNINGHAM, MARION MORGAN (J) technical service director, Bendix Brake Co., 401 Bendix Drive, *South Bend, Ind.*

CUETICE, H. H. (A) president, general manager, A. C. Spark Plug Co., Harriet Street, *Flint, Mich.*

DALAND, ELLIOT (M) engineer, Keystone Aircraft Corp., Bristol, Pa.; (mail) Crestmount Farms, *Torresdale, Philadelphia.*

DALTON, CHARLES J. (M) owner, Madison Avenue at 135th Street, *New York City.*

DANZINGER, J. R. F. (J) draftsman, fuselage department, Glenn L. Martin Co., Baltimore; (mail) 56 Admiral Boulevard, *Dundalk, Md.*

DIVER, BERTICE M. (M) general hustler, 810 Stephenson Building, Grand Boulevard and Cass, *Detroit.*

DRANGEID, RAGNVALD O. (M) body draftsman, improvements and design, Cadillac Motor Car Co., *Detroit;* (mail) 3036 Northwestern Avenue.

EARHART, AMELIA (MISS) (A) assistant general traffic manager, Transcontinental Air Transport, 959 Eighth Avenue, *New York City.*

EARMAN, E. N. (J) in charge of material-returned department, Chevrolet Motor Co., *Flint, Mich.;* (mail) 228 Third Avenue.

EKSERGIAN, C. L. (M) chief engineer, Budd Wheel Co., 12141 Charlevoix Avenue, *Detroit.*

EMERY, JOHN C. (M) motor-transport editor, Simmons-Bordman Publishing Co., 105 West Adams Street, *Chicago.*

FILMER, EDWARD (A) motor engineer, Parkfield Garage, Manchester, England; (mail) 4 Ash Walk, Alkrington, *Middleton, England.*

FREY, RUDOLF (J) draftsman, Western Reserve Air Motors Corp., Bramley Power Building, *Lakewood, Ohio.*

FUNKHOUSER, MEARICK (J) student, Cornell University, *Ithaca, N. Y.;* (mail) Sigma Alpha Epsilon House.

GOODYEAR, CLAUDE EUGENE (F M) works director, Dunlop Rim & Wheel Co., Ltd., Foleshill, *Coventry, England.*

GRAEBNER, OTTO F. (M) chief engineer, Murray Corp. of America, 1424 Aberle Street, *Detroit.*

HARMON FRANK J. (A) branch manager, International Harvester Co. of America, *Philadelphia;* (mail) International Harvester Co. of America, Erie Avenue and F Street.

HATFIELD, CHARLES EDWARD (J) tracer, upkeep department, American Rolling Mill Co., *Ashland, Ky.;* (mail) 232-34th Street.

HAWTHORN, JOHN (A) service manager, superintendent, engineer, Canadian branches, Leyland Motors, Ltd., 593 King Street, East, *Toronto, Ont., Canada.*

HAZARD, ALBERT C. (J) engineer, motor plant, General Motors of Canada, Ltd., *Walkerville, Ont., Canada.*

HEINZE, ALBERT F. (A) salesman, Autocar Sales & Service Co., 1801 South Main Street, *Los Angeles.*

HEXEL, LEOPOLD J. (J) chassis layout draftsman, Chrysler Corp., *Detroit;* (mail) 2720 Florian, *Hamtramck, Mich.*

HIBBARD, HALL L. (J) engineer, Stearman Aircraft Co., *Wichita, Kan.*

HODGSON, SAMUEL KINDLEY (J) project engineer, engineering department, Spartan Aircraft Co., *Tulsa, Okla.*

HUNSAKER, JOHN F. (A) salesman, Kelly-Springfield Tire Co., *San Francisco;* (mail) 3320 Octavia.

JACK, WILLIAM A. (J) engineer, Burgess Battery Co., *Madison, Wis.*

JOHNSON, STEPHEN, JR. (M) general engineer, automotive brake division, Westinghouse Air Brake Co., 5001 Centre Avenue, *Pittsburgh.*

JOUFFRET, HENRI (F M) ingénieur d'études, Société Anonyme André Citroen, Paris, (mail) 3 Rue Amiral de Joinville, *Neuilly sur Seine, France.*

KAMINSKY, PAUL M. (A) proprietor, Carlye Rubber Co., New York City; (mail) 487 Humboldt Street, *Brooklyn, N. Y.*

KITTLER, MILTON J. (J) engineer, experimental department, International Harvester Co., *Chicago;* (mail) 2116 Hudson Avenue.

KNOHL, FRIEDRICH KARL (J) truck designer, Fargo Motors Division, Chrysler Motor Co., Highland Park, Mich.; (mail) 1001 Summit, *New Haven, Ind.*

KOBINATA, EIJIRO (F M) mechanical engineer, Japanese Government Railways, Tokyo, Japan; (mail) 228 Ichikawa Mama, *Chibaken, Japan.*

KONONOFF, ALEXIS B. (J) student engineer, Buick Motor Co., *Flint, Mich.;* (mail) 404 Mary Street.

LENNSTRAND, GUY S. (A) supervisor, Dodge division, Chrysler Corp., London; (mail) American Club, 95 Piccadilly, *London, W 1, England.*

LOENING, ALBERT PALMER (A) vice-president, director, Loening Division, Keystone Aircraft Corp., 31st Street and East River, *New York City.*

MACCARTHY, JOHN J. (M) president, chief engineer, Murray Motor Car Co., *Malden, Mass.;* (mail) 55 Wicklow Street.

MACKLIN, DONALD JAMES (M) designing engineer, in charge of engine design and development work, Autocar Co., *Ardmore, Pa.*

MAST, W. A. (A) shop foreman, Globe Garage, *Spokane, Wash.;* (mail) 827 East Gordon Avenue.

MCBRIDE, JAMES BURTON (A) sales clinic instructor, Ford Motor Co. of Canada, *Toronto, Ont., Canada;* (mail) 319 Brunswick Avenue.

MENTON, MARTIN (M) head of tool engineering, Harper plant, LeBaron, Inc., *Detroit;* (mail) 129 Hildale, West.

MERRILL, EDWARD D. (M) president, general manager, Washington Rapid Transit Co., 4615 14th Street, Northwest, *City of Washington.*

MOODY, WILMER E. (A) chief inspector, General Motors Truck Co., Pontiac, Mich.; (mail) 635 Harmon Avenue, *Birmingham, Mich.*

NUNN, EWING D. (A) secretary, in charge of experimental work, Nunn-Landon Co., Inc., *Milwaukee;* (mail) 445 Kenwood Boulevard.

PIWONKA, WILLIAM G. (J) engineer, motor-coach department, Cleveland Railway Co., *Cleveland;* (mail) 1809 St. Clair Avenue.

PURDY, ALVIN CANFIELD (M) general partner, Bull & Roberts, 50 West Street, *New York City.*

RAYCROFT, RICHARD IRVING (A) in charge of manufacturers equipment tire sales, Firestone Tire & Rubber Co. of Canada, Ltd., Beach Road, *Hamilton, Ont., Canada.*

RIEGEL, F. ALEXANDER (A) engineering contact for export at domestic plants, General Motors Export Division, General Motors Corp., New York City; (mail) 1521 Cromwell Boulevard, *Flint, Mich.*

ROBERTSON, RALPH N. (M) mechanical engineer, Blaw-Knox Co., *Pittsburgh;* (mail) P. O. Box 915.

ROSSMAN, EDWIN F. (M) engineer, shock-absorbers, Delco Products Corp., *Dayton, Ohio.*

ROTTER, MAX (M) vice-president, in charge of engineering, Busch-Sulzer Bros.-Diesel Engine Co., St. Louis; (mail) 428 Jefferson Street, *Milwaukee.*

RUSKIN, HENRY (M) draftsman, Curtiss Aeroplane & Motor Co., *Buffalo;* (mail) 14 Cambridge Avenue.

SCHJOLIN, HANS O. (M) project engineer, General Motors Truck Co., *Pontiac, Mich.*

SCHUCKER, OSCAR O. (A) service manager, H. F. Gleason Motors, Inc., *Pittsburgh;* (mail) 1916 Remington Drive.

SIBERT, CHARLES J. (A) engineering department, General Electric Co., 230 South Clark Street, *Chicago.*

SMITH, WARREN H. (J) junior engineer, General Motors Corp. Research Laboratories, *Detroit;* (mail) 66 Piquette Avenue.

STEENECK, ROBERT F. (A) western representative, shackle division, Fafnir Bearing Co., New Britain, Conn.; (mail) 57 California Street, *San Francisco.*

STREHLOW, WALTER F. (M) engineer, Allis-Chalmers Mfg. Co., *Milwaukee.*

SUCZEK, ROBERT (M) research engineer, Cadillac Motor Car Co., *Detroit;* (mail) 1023 Kensington Road, Grosse Pointe Park.

SWARTZ, HUGH (A) owner, Hugh Swartz, Inc., Dual Oil Burner Co., *Seattle, Wash.;* (mail) 1130 Broadway.

SWIFT, MORTON C. (J) test engineer, Pratt & Whitney Aircraft Co., Hartford, Conn.; (mail) 185 Lincoln Street, *New Britain, Conn.*

TAYLOR, ALLEN (A) service manager, Minerva Automobile, Inc., New York; (mail) 284 South Columbus Avenue, *Mount Vernon, N. Y.*

(*Concluded on p.* 411)

Applicants for Membership

The applications for membership received between Jan. 15 and Feb. 15, 1930, are listed below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ACKER, HAROLD L., aeronautic draftsman, Naval Aircraft Factory, Navy Yard, *Philadelphia.*

AKIN (MRS.), GLADYS M., technical data statistician, United States Rubber Co., *Detroit.*

ANDERSON, JOSEPH L., designing and layout draftsman, Vimalert Co., Ltd., *Jersey City, N. J.*

ASSENMACHER, JOSEF, designing engineer, New Standard Aircraft Corp., *Paterson, N. J.*

BELLINGHAM, WILLIAM JAMES, service manager, General Motors Truck & Coach Division, *Toronto, Ont., Canada.*

BOLAM, JOHN GEORGE, motor superintendent, Anglo-American Oil Co., Ltd., *London, England.*

BOURGEOIS, ERNEST JOSEPH, assistant research engineer, Standard Oil Development Co., *Elizabeth, N. J.*

BOYER, GEORGE HEWITT, automotive engineer, Vacuum Oil Co., *Milwaukee.*

BRIDGEMAN, OSCAR C., research associate, Bureau of Standards, *City of Washington.*

BROEKHUYSEN, EGBERT, J. M., Coenenstraat 35, *Amsterdam Zuid, Holland.*

BURKART, HANS, diploma engineer, member of American staff, International General Electric Co., *Schenectady, N. Y.*

CHENAULT, A. H., engineer, Ethyl Gasoline Corp., *Detroit.*

CLARK, NEIL DOW, instructor, automobile mechanics, Milwaukee Vocational School, Board of Industrial Education, *Milwaukee.*

COLLIER, WILLIAM JOHN, service division, Graham-Paige Motor Corp., *Detroit.*

DAVIS, WALTER C., president, Davis Aircraft Corp., *Richmond, Ind.*

DIERCK MEIER, R. L., central district manager, The Heil Co., *Milwaukee.*

DUNCAN, ANDREW J., draftsman, checker in charge of door-closers, Norton-Blair-Douglass, *New York City.*

FRAZER, ARTHUR W., president, Auto Starter Co., Ltd., *Toronto, Ont., Canada.*

GALLOWAY, R. M., chief engineer, National Automatic Tool Co., *Richmond, Ind.*

GERLAT, OSCAR HENRY, member of engineering faculty, Marquette University, *Milwaukee.*

GOLDICH, DAVID E., New England manager, E. I. duPont deNemours & Co., *Boston.*

GROFF, JOSEPH C., engineer, oil and gas engine division, Bethlehem Steel Co., *Bethlehem, Pa.*

GUEST, JOHN ADOLPHUS, marine superintendent, inspector of launches, H. M. Customs, *Rangoon, Burma, India.*

HALSTEAD, FRED H., engineer, Ramsey Shain Co., *Albany, N. Y.*

HENDRICKSON, HUGH L., assistant engineer, Braden Steel & Winch Co., *Tulsa, Okla.*

HERSEY, DONALD SAMUEL, assistant aeronautical engineer, Pratt & Whitney Aircraft Co., *Hartford, Conn.*

HORNNEY, ALVAN GEORGE, sales engineer, American Machine & Foundry Co., *New York City.*

HORTON, C. R., inspection of aircraft woods and layout draftsman, Spartan Aircraft Corp., *Tulsa, Okla.*

HUBING, EUGEN, factory manager, Motor Truck Works, *Braunschweig, Germany.*

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JONES, B. FRANK, truck engineer, Pierce-Arrow Motor Car Co., *Buffalo.*

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LANGLEY, RALPH H., director of engineering, Crosley Radio Corp., *Cincinnati.*

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LICKERT, MARVIN E., layout man, DeVilbiss Mfg. Co., *Toledo, Ohio.*

LONG, ARTHUR F., service manager, Manley Auto Co., *Portland, Ore.*

LUNDBERG, EVERETT E., chief engineer, Briggs Mfg. Co., *Detroit.*

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MCALEXANDER, ALBERT W., service-station foreman, International Harvester Co. of America, *Memphis, Tenn.*

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OTT, BURL E., Automotive and Aeronautics Institute, Board of Education, *Detroit.*

PELL, THOMAS E., factory superintendent, Berliner Joyce Aircraft Co., *Dundalk, Mo.*

PRICE, E. T., chief engineer, Acme Motor Truck Corp., *Cadillac, Mich.*

REDDIG, JAMES C., engineer, Grover Loening Co., *New York City.*

REYNOLDS, FLOYD L., lubrication engineer, aeronautical division, Vacuum Oil Co., *New York City.*

RICKLES, NATHANIEL H., mechanical engineer, Standard Oil Development Co., *Elizabeth, N. J.*

ROLAN, GEORGE TRAVIS, Cadillac service, Cadillac Motor Car Co. of Canada, Ltd., *Oshawa, Ont., Canada.*

ROSE, FRANK A., in charge of cars, trucks and equipment, Leo Greenbaum, *San Diego, Calif.*

SCHAMEHORN, A. J., director, General Motors Proving Ground, *Milford, Mich.*

SCHECHTER, BEN, chief engineer, American Car Co., *St. Louis.*

SHAW, SAMUEL ERVINE, maintenance test, Rolls-Royce of America, Inc., *Long Island City, N. Y.*

SPENGLER, WALTER J., chief engineer, Scintilla Magneto Co., Inc., *Sidney, N. Y.*

SPOHR, CARL W., chief draftsman, Vacturi Carburetor Co., *Chicago.*

STACEY, HERBERT RICHARD, research engineer, Standard Oil Development Co., *Linden, N. J.*

STAFFORD, ROBERT LESLIE, sales engineer and technical assistant to directors, W. H. Dorman & Co., Ltd., *Stafford, England.*

STAROST, JOHN C., shop engineer, Marmon Motor Car Co., *Indianapolis.*

STEWART, GEORGE W., retail passenger sales manager, Frank D. Saupp, Inc., *Pittsburgh.*

STOUGH, GERALD D., assistant engineer, aircraft department, Standard Steel Works, *North Kansas City, Mo.*

STRONG, JOHN RUSSELL, foreman, Steel Products Engineering Co., *Springfield, Ohio.*

TAYLOR, CLARENCE PARKER, assistant traffic engineer, Commonwealth of Massachusetts, Department of Public Works, *Cambridge, Mass.*

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VOLLHEIM, WILLIAM, draftsman, Fairbanks, Morse & Co., *Beloit, Wis.*

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WEISEL, JOHN L., chief engineer, Menasco Motors, Inc., *Los Angeles.*

WETZEL, CHARLES G., superintendent of body building, Peerless Motor Car Corp., *Cleveland.*

WHEELER, P. R., junior aeronautical engineer, United States Bureau of Standards, *City of Washington.*

WHIPPLE, CLARENCE WILLIAM, motor and aeroplane mechanic, Allison Aeroplane Co., *Lawrence, Kan.*

WILDEMAN, STEPHEN, assistant powerplant, engineer, The Buda Co., *Harvey, Ill.*

WILEY, VERIL O., head of automobile department, Pullman Free School of Manual Training, *Chicago.*

WILLIAMS, JAMES R., pilot, aircraft sales and field service, Greenfield Tap & Die Corp., *Greenfield, Mass.*

WILSON, ROY J., special equipment engineer, general sales department, Mack-International Motor Truck Corp., *New York City.*

WOLFE, FRANK J., general manager, Atzberger & Wolfe, *East Islip, L. I., N. Y.*

WRAIGHT, ROBERT DOUGLAS, general service manager, Todd Motor Co., *Wellington, New Zealand.*

Applicants Qualified

(*Concluded from p.* 410)

TEICHERT, CONRAD A. (J) engine designer, mathematician, International Harvester Co., *Fort Wayne, Ind.*; (mail) 2525 Warsaw Street.

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VULTEE, GERARD F. (M) chief engineer, Lockheed Aircraft Corp., *Burbank, Calif.*; (mail) Box 1117.

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WILLIS, ROSS E. (A) sales manager, Ready-Power Co., 3826 Grand River Avenue, *Detroit.*

WISE, WILLIAM FREDERIC (M) sales manager, Ex-Cell-O Aircraft & Tool Corp., 1200 Oakman Boulevard, *Detroit.*

WOOD, L. F. (A) vice-president, Crown-Dominion Oil Co., Ltd., Gage Avenue, South, *Hamilton, Ont., Canada.*

Notes and Reviews

AIRCRAFT

Flow and Force Equations for a Body Revolving in a Fluid. By A. F. Zahm. Report No. 323. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 41 pp., 17 figures. [A-1]

This report, submitted to the National Advisory Committee for Aeronautics for publication, is a slightly revised form of United States Navy Aerodynamical Laboratory Report No. 380, completed for the Bureau of Aeronautics in November, 1928.

Part 1 gives a general method for finding the steady-flow velocity relative to a body in plane curvilinear motion, whence the pressure is found by Bernoulli's energy principle. Integration of the pressure supplies basic formulas for the zonal forces and moments on the revolving body. Part 2, applying this steady-flow method, finds the velocity and pressure at all points of the flow inside and outside an ellipsoid and some of its limiting forms, and graphs those quantities for the latter forms. In some useful cases experimental pressures are plotted for comparison with theoretical pressures. Part 3 finds the pressure, and thence the zonal force and moment, on hulls in plane curvilinear flight. Part 4 derives general equations for the resultant fluid forces and moments on trisymmetrical bodies moving through a perfect fluid, and in some cases compares the moment values with those found for bodies moving in air. Part 5 furnishes ready formulas for potential coefficients and inertia coefficients for an ellipsoid and its limiting forms. Thence are derived tables giving numerical values of those coefficients for a comprehensive range of shapes.

Full-Scale Turning Characteristics of the U. S. S. Los Angeles. By F. L. Thompson. Report No. 333. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 14 pp. [A-1]

This paper presents a description of the method employed and results obtained in full-scale turning trials on the rigid airship U. S. S. Los Angeles.

The results of this investigation are not sufficiently comprehensive to enable definite conclusions to be drawn as to the variation of turning characteristics with changes in speed and rudder angle. They indicate, however, that the turning radius compares favorably with that for other large airships, that the radius is independent of the speed, that the position of the point of zero yaw is nearly independent of the rudder angle and air-speed, and that a theoretical relation between radius and angle of yaw in a turn gives a close approximation to actuality. The method of determining turning characteristics by recording instruments aboard the airship seems to be satisfactory, with the exception that a better method of determining the small angular velocities of airships should be devised.

These items, which are prepared by the Research Department, give brief descriptions of technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

The letters and numbers in brackets following the titles classify the articles into the following divisions and subdivisions: *Divisions*—A, Aircraft; B, Body; C, Chassis Parts; D, Education; E, Engines; F, Highways; G, Material; H, Miscellaneous; I, Motorboat; J, Motorcoach; K, Motor-Truck; L, Passenger Car; M, Tractor. *Subdivisions*—1, Design and Research; 2, Maintenance and Service; 3, Miscellaneous; 4, Operation; 5, Production; 6, Sales.

Aerodynamic Theory and Test of Strut Forms. Part II. By R. H. Smith. Report No. 335. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 41 pp., 40 figures. [A-1]

In this report five theoretical struts are developed from distributed sources and sinks and constructed for pressure and resistance tests in a wind-tunnel. The surface pressures for symmetrical inviscid flow are computed for each strut from theory and compared with those found by experiment. The theoretical and experimental pressures are found to agree quantitatively near the bow; only qualitatively over the suction range, the experimental suctions being uniformly a little low; and not at all near the stern.

This study is the strut sequel to Fuhrmann's research on airship forms, the one being a study in two dimensions, the other in three. A comparison of results indicates that the agreement between theory and experiment is somewhat better for bodies of revolution than for cylinders when both are shaped for slight resistance.

Part I of this study appeared as Report No. 311.

Combating Airplane Fires. By Henri Brunat. Technical Memorandum No. 550; translated from a booklet published by the Comité Francais de Propagande Aéronautique; 18 pp., illustrated. [A-1]

Relation Between the Stability Characteristics and the Controllability of German Airplanes. By Walter Hübner. Technical Memorandum No. 551; translated from *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Oct. 28, 1929; 23 pp., illustrated. [A-1]

Wind - Tunnel Pressure - Distribution Tests on a Series of Biplane Wing Models. Part III—Effects of Changes in Various Combinations of Stagger, Gap, Sweepback and Decalage. By Montgomery Knight and Richard W. Noyes. Technical Note No. 330; 6 pp., 36 figures. [A-1]

The foregoing two Technical Memoranda and Technical Note concerning airplane design were issued during January by the National Advisory Committee for Aeronautics, City of Washington.

L'Hélice Métallique Ratier à Pas Variable en Vol. By Pierre Léglise. Published in *L'Aéronautique*, December, 1929, p. 411. [A-1]

The Ratier controllable-pitch propeller has for its most notable feature, according to this description, a method of pitch adjustment designed for ease of operation. In explaining the theory of the pitch-adjusting scheme, the author analyzes the centrifugal force acting on the blade. One of its components, he states, has an outward thrust along the axis of the blade; the other, perpendicular to this, tends to make the blade turn on its own axis, thus making it relatively difficult to adjust the angle of incidence in one direction and easy in the other. This latter component, usually ignored, is specifically taken into account in the design of the Ratier propeller.

The distinguishing feature of the adjusting mechanism is that the socket into which the propeller fits is provided with helicoidal ball-bearing races. The direction of these is such that the torsion couple tends to screw the blade into the socket in opposition to the centrifugal force which tends to unscrew

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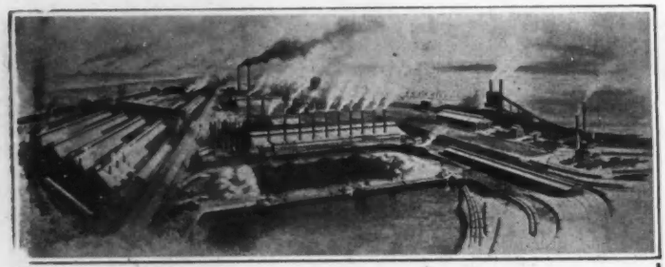

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Notes and Reviews

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it; also, the thread is designed so that it counteracts both components in proportion to their force.

Manufacturers of the Ratier propeller are planning to fit to it an electric control device and to provide on the instrument board a pitch indicator. One of the propellers, mounted on a 450-hp. Lorraine engine, has successfully passed a 30-hr. test at speeds varying from 1800 to 1850 r.p.m. Adjustments of the angle of incidence of the order of 20 deg. were made with ease at all speeds.

Die Joukowskysche Wirbeltheorie des Propellers und ihre Verwendung zur Berechnung von Luftschrauben. By W. Alexandrow. Published in *Zeitschrift für Flugtechnik und Motorluftschiffahrt*, Dec. 28, 1929, p. 633. [A-1]

This article treats of the Joukowsky vortex theory of propellers and its use in the design of airscrews. The Russian theories concerning the pusher type of propeller are reviewed. The fundamentals of the Joukowsky theory are explained and examples given of how actual observations have checked calculations made according to the theory.

Next to be dealt with are the forces that come into play when the propeller is used on an aircraft, as distinguished from its operation as a single independent element. The deformation of the propeller due to aerodynamic and inertia forces is analyzed. Finally, the application of the theory to devices other than propellers but having similar characteristics is illustrated. Fans are used as a specific example.

A Narrative History of Aviation. By John Goldstrom. Published by the Macmillan Co., New York City, 1930; 319 pp.; 50 illustrations. Price, $4. [A-3]

Any attempt to tell the story of aviation in a single volume must confine itself to the selection of outstanding events and developments. The author begins in the opening chapter with the struggles of prehistoric man and ends the book with an account of the advanced position of aviation at the present time.

First, the trials and successes of the Wright brothers are recorded, with an explanation of the Wright-Langley dispute. Then are narrated some of the famous early flights across the English Channel, the part aviation played during the World War, the results it achieved in advancing aeronautics, and the experiences of air aces.

The development of the air-mail service in the United States is also outlined and in the following chapter short, thrilling accounts are given by some of the air-mail pilots of averted accidents and narrow escapes from death.

Transoceanic flights of such famous fliers as Lindbergh, Chamberlin, Maitland and Hegenberger, Dr. Hugo Eckener and others are described. The accomplishments of Byrd and Amundsen in the polar regions are also brought to the fore in a chapter devoted to this topic.

The transport activities in individual European and other countries are outlined in two chapters.

A separate chapter chronicles women's activities in aviation, such as the first aerial passenger to ascend in a Montgolfier balloon; the first to fly in an airplane as a passenger with Wilbur Wright; the first to fly as a passenger across the Atlantic, namely, Amelia Earhart; and the first to cross the Atlantic as passengers in the Graf Zeppelin. Other famous fliers are also given attention, among these being Harriet Quimby, the first feminine flier to cross the English Channel, Lady Heath and Lady Bailey, and Mrs. Thaden.

The final chapters point out the rapid progress made by the airplane and the various developments that have made aircraft safer,

At the end of the book the author has appended a list of the official world records of landplanes and seaplanes, and a classified bibliography.

(*Continued on next left-hand page*)

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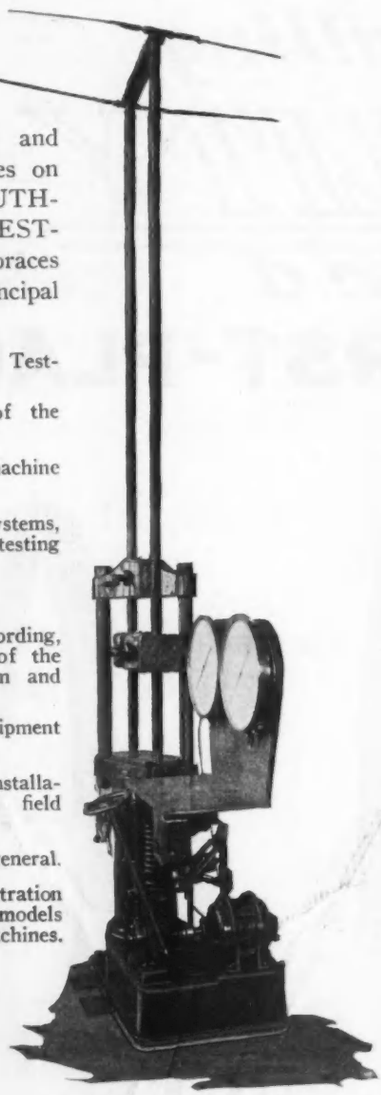

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CHASSIS PARTS

A Study of Fatigue Cracks in Car Axles. Part II. Herbert F. Moore, Stuart W. Lyon and Norville J. Alleman. Bulletin No. 197, Engineering Experiment Station, University of Illinois, Urbana, Ill., November, 1929; 27 pp., illustrated. [C-1]

In 1924 the Utilities Research Commission entered into cooperative relation with the University of Illinois for the study of fatigue failures of car axles under repeated stress. One bulletin concerning the work of this investigation has previously been published. The present bulletin deals especially with the practical question whether it is safe to use axles in which small fatigue cracks have started, if these axles are turned down below the bottom of the fatigue cracks and then put into service for which a smaller axle of sound steel would be safe. In other words, does the damaging effect of a fatigue crack injure the steel below the bottom of the crack and, if so, to how great a depth?

As a result of a series of tests on six different axles and tests on specimens of two sizes, the conclusion was reached that the practice of salvaging an axle by turning it down to a smaller size is safe if material is removed to the depth of at least 1/16 of an inch below the apparent bottom of the fatigue crack. The authors are convinced that if material is removed to only the apparent bottom of the fatigue crack, all the damaged material is not removed and therefore the fatigue strength of an axle so treated may be considerably less than would be expected from the fatigue strength of the virgin steel.

The tests showed that the beneficial effects of heat-treatment are appreciable well in toward the center of a solid piece of steel as large as a car axle; that is, about 6¼ in. in diameter.

Wheel Wabble. By A. G. Douglas Clease, B.Sc. Published in *The Autocar*, Nov. 29, 1929, p. 1184. [C-1]

The author reviews the latest available data on the subject of wheel wabble and presents various technical considerations of the problem. In the first part of the article, a paper on the subject by A. Healey, presented before the Institution of Automobile Engineers, is discussed. In the second part, which appeared in the Dec. 6 issue of *The Autocar*, research work by Professor Becker, of the Berlin Technical School, is described.

ENGINES

Experimental and Analytical Determination of the Motion of Hydraulically Operated Valve-Stems in Oil-Engine Injection Systems. By A. G. Gelalles and A. M. Rothrock. Report No. 330. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 20 pp., 12 figures. [E-1]

This research on the pressure variations in the injection system of the N. A. C. A. spray-photography equipment and on the effects of these variations on the motion of the timing-valve stem was undertaken in connection with the study of fuel-injection systems for high-speed oil engines. The spray-photography equipment employed for these tests consists of a fuel-injection system for producing an oil spray, an electrical spark system for illuminating the spray, and a camera for recording the development of the spray. The fuel-injection system contains a high-pressure hand-pump for producing the injection pressures, an oil reservoir for maintaining the pressures of the fuel during the injection, a valve for timing the start of the oil spray, an injection valve for atomizing the oil, and a bypass valve for controlling the cut-off of the spray. Additions were made to the apparatus so as to record the motion of the timing-valve stem photographically.

The timing-valve stem was held against its seat by a helical spring adjusted so that the total hydraulic force on the stem actuated it immediately after it had been me-

(*Continued on next left-hand page*)

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Notes and Reviews

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chanically lifted from its seat. The lift of the stem was recorded photographically to determine the effects of injection tubes 7 in. and 43 in. long. The pressure variations at the seat and in the injection-valve tubes were analyzed and the lifts of the stem for both tubes computed from the analysis and compared with the experimental records.

The methods of analysis of the pressure variations and the general equation for the motion of the spring-loaded stem for the timing valve are applicable to a spring-loaded automatic-injection valve and, in general, to all hydraulically operated valves. A sample calculation for a spring-loaded automatic-injection valve is included.

The Effect of Cowling on Cylinder Temperatures and Performance of a Wright J-5 Engine. By Oscar W. Schey and Arnold E. Biermann. Report No. 332. Published by the National Advisory Committee for Aeronautics, City of Washington, 1930; 22 pp., 16 figures. **[E-1]**

This report presents the results of tests conducted to determine the effect of different amounts and kinds of cowling on the performance and cylinder temperatures of a standard Wright J-5 engine. The tests were conducted in conjunction with drag and propeller tests in which the same cowlings were used.

The engine was mounted in the nose of a cabin fuselage and placed in the airstream of the Committee's 20-ft. propeller-research tunnel.

Four different cowlings were investigated in the tests herein reported, varying from the one extreme of no cowling on the engine to the other extreme of the engine completely cowled and the cooling-air flowing inside the cowling through an opening in the nose and out through an annular opening at the rear of the engine. Each cowling was tested at air-speeds of approximately 60, 80, and 100 m.p.h.

For the conventional type of engine cowling, the results of these tests indicate that increasing the amount of cowling has the advantage of reducing the drag but the disadvantage of increasing the cylinder-barrel temperatures. Satisfactory cooling was obtained with the conventional cowling that covered 35 per cent of the cylinder cooling-area.

For the cabin fuselage with the N. A. C. A. cowling which completely enclosed the engine and took in all of the cooling air through a 28-in.-diameter opening in the nose, the drag was reduced 40 per cent at 100 m.p.h., as compared with the same unit having no cowling on the engine.

Contribution to the Study of Normal Burning in Gaseous Carbureted Mixtures. Part II. By M. R. Dûchene. Translated from *Service Technique et Industriel de l' Aéronautique Bulletin Technique* No. 54, December, 1928. Technical Memorandum No. 548; 35 pp., 25 figures. **[E-1]**

Coefficients of Flow of Standard Nozzles. By H. Mueller and H. Peters. Translated from *Zeitschrift des Vereines deutscher Ingenieure*, No. 27, 1929. Technical Memorandum No. 549; 6 pp. **[E-1]**

Injection Lags in a Common-Rail Fuel-Injection System. By A. M. Rothrock. Technical Note No. 332; 7 pp., 7 figures. **[E-1]**

The two Technical Memoranda and the Technical Note listed above relating to engine design were issued during January by the National Advisory Committee for Aeronautics, City of Washington.

Un Moteur à Huile Lourde à Régime Rapide: Le Moteur Held. By A. Caputo. Published in *Omnia*, January, 1930, p. 562. **[E-1]**

Experiments with fuel injected into a bomb filled with compressed air were made by Professor Held, of the Technologic Institute of Petrograd, prior to the development of

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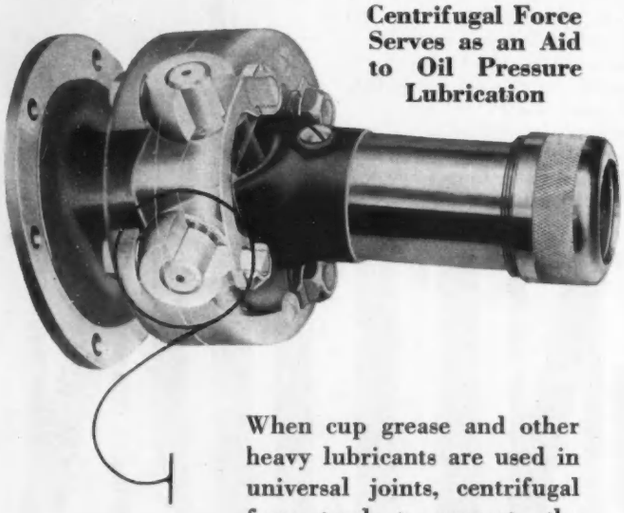

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Notes and Reviews

Continued

his high-speed heavy-oil engine. They were made to throw light on the spontaneous-ignition temperature at different pressures, the supply of air necessary for complete combustion and the speed of combustion at the moment of spontaneous ignition.

The distinctive feature of the two-stroke-cycle engine developed as a result of these experiments is the shape of the combustion-chamber. The surface of the piston-head is made of two semicylindrical depressions, and the cylinder-head is correspondingly arched, so that when the piston is at top dead-center position the combustion-chamber is in the shape of two complete cylinders. The method of fuel injection is designed to produce extremely active turbulence. The ingoing air is heated by passage over the exhaust manifold.

Results are given of tests made on an engine of this type, a two-cylinder 90 x 110 mm. (3.54 x 4.37 in.), with a compression ratio of 8.5:1. The compression pressure was about 18 atmospheres, while the maximum combustion pressure did not exceed 29 atmospheres. The weight of the engine empty is 100 kg. (220 lb.) with an aluminum cylinder-block, and 130 kg. (286 lb.) with a cast-iron cylinder-block. Tests were made using different fuels. With gas-oil as fuel, the engine attained 20 hp. at 2400 r.p.m. on a fuel consumption of 300 grams (10.58 oz.) per hp-hr.

Gaseous Explosions. Part VIII—Effect of Tetraethyl Lead, Hot Surfaces, and Spark Ignition on Flame and Pressure Propagation. By Mott Souders, Jr., and G. G. Brown. Published in *Industrial and Engineering Chemistry*, December, 1929, p. 1261. **[E-1]**

The effect of tetraethyl lead, both in the vapor phase and thermally decomposed, on flame-speeds and rate of pressure rise following ignition, was determined for explosive mixtures of benzene, pentane, isohexane, and heptane in air. According to the authors, tetraethyl-lead vapor was ineffective in retarding combustion until it was decomposed by the burning mixture, whereas decomposed tetraethyl lead, introduced before firing the charge, retarded both flame-speed and rate of pressure rise.

A hot surface was introduced into the bomb to secure auto-ignition of the charge ahead of the advancing flame. This auto-ignition produced an unusually high rate of pressure rise. Decomposed tetraethyl lead prevented or delayed the auto-ignition and retarded the resulting combustion. High-frequency pressure waves ordinarily present in the explosions were eliminated by decreasing the number of sparks in the igniting discharge. The effect of these waves on the combustion and on the initiation of a violent shock-wave was determined.

Le Rôle Capital de la Turbulence dans la Recherche du Rendement et de la Puissance. By A. Darche. Published in *La Technique Automobile et Aérienne*, Third Quarter, 1929, p. 65. **[E-1]**

Injecting himself into the argument as to the rôle played by turbulence in combustion, this author takes as his theme the statement that "It is precisely through this factor that perhaps can most easily be realized a vitally important improvement in the essential qualities of an automotive engine."

After analyzing the theoretical and real thermal cycle, he presents arguments for the introduction of turbulence from the viewpoint of improved combustion, prevention of detonation and the general flexibility and responsiveness of the engine. He goes into the four versus six-cylinder controversy, treating it under the heads of flexibility, acceleration, deceleration, vibration, regularity of engine torque and power. He concludes that "in four-cylinder engines of from 1.5 to 2-liters displacement (90 to 120 cu. in.) the use of supplementary turbulence will enable a legion

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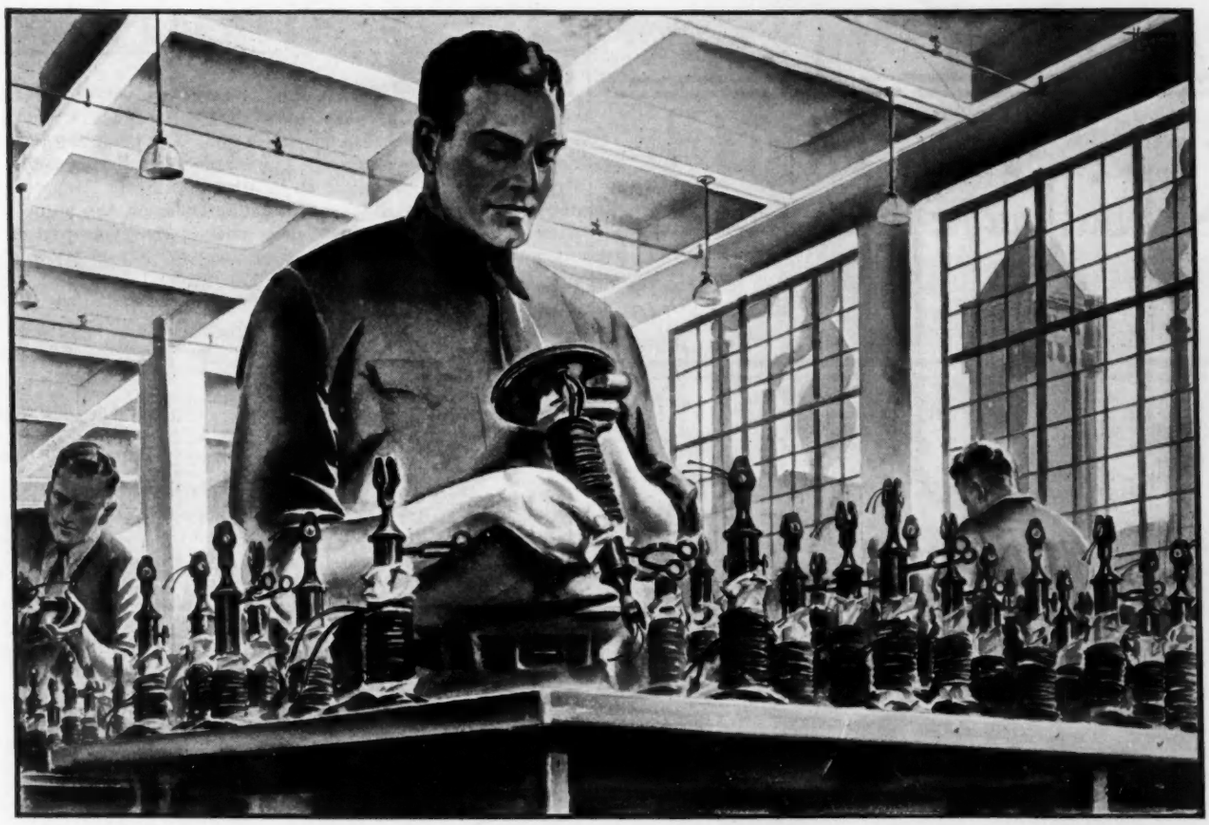

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Notes and Reviews

Continued

of motorists of moderate means to enjoy all the pleasures of driving the equivalent of a six-cylinder car without the least increase of expense, but, on the contrary, with a noticeable fuel economy. The same expedient, applied to French cars of from 2 to 3 liters (120 to 180 cu. in.), of six or eight cylinders, will place them on the same plane with the best American cars with twice the piston displacement."

Supplementary turbulence is defined as turbulence produced by such means as combustion-chamber design, as distinguished from natural turbulence due to the introduction of the air-fuel mixture into the cylinders at high speed.

Oil-Engine Powerplant Handbook. Fifth Edition. Edited by Julius Kuttner, B.Sc. Published by *Oil-Engine Power*, New York City. Price $5. **[E-3]**

The material in this volume is classified under three divisions; namely, a Diesel Operating Manual, Diesel Plant Accessories, and Diesel Uses and Economics. The manual contains valuable pointers on the operation and maintenance of fuel-pumps and injection systems; pistons, cylinders and rings; main bearings; and air compressors. Under Diesel Plant Accessories are chapters on Air Filtration, Oil Centrifuging, Exhaust Systems, Cooling Towers, and Instruments and Measuring.

The catalog section has been prepared in cooperation with the manufacturers and gives pertinent data on Diesel engines and oil engines available on the American market. This section is provided with both an alphabetical and an advertising index.

MATERIAL

Dewaxing of Lubricating Oils. By E. R. Lederer and R. Beattie. Paper presented at the tenth annual meeting of the American Petroleum Institute, Chicago, Dec. 5, 1929. **[G-1]**

The phenomenal growth of aviation, which makes it possible for an airplane to leave a temperate zone and the same day land in a frigid zone, together with the constantly increasing use of automobiles in winter, has led to improved dewaxing methods, the authors point out. A comparison of the Weir filtration method with centrifuging or cold settling, based on experimental data, is drawn and supplementary consideration is given to the economic aspect in production.

Les Charactéristiques Mécaniques du Caoutchouc Manufacturé. By Edmond Marcotte. Published in *Le Génie Civil*, Dec. 7, 1929, p. 557. **[G-1]**

To supply the lack of disinterested data on the properties of manufactured rubber, the present article sets forth the results of research and practical experience at the school of bridge and highway construction.

The results of former work are recited as a background: tension tests and the effects of additions to the rubber of organic or mineral substances; compression tests; elastic deformation tests, and conclusions that may be formed from the data.

At the laboratory of the school of bridge and highway construction, extension tests led to the conclusion that good rubber may easily double its length. Compression tests included, first, cubes pressed between two parallel plates and then between two opposed V-shaped forms, in each case the effect of modifying the surface of the specimen with lubricant being studied.

Interesting results were obtained from the observation under compression of three superimposed discs and a prism. Practical tests included those on a hollow cylinder intended for use as a shock-absorber on machines of various types.

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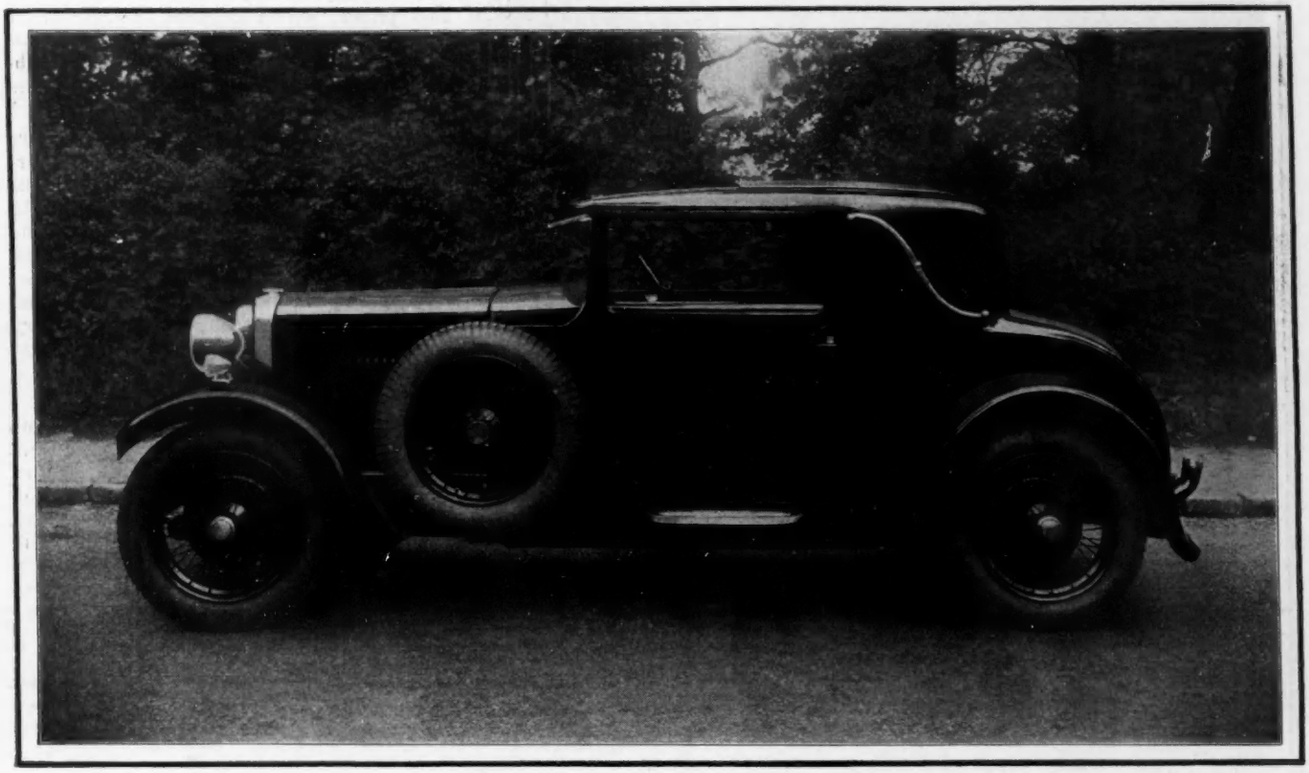

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Notes and Reviews

Continued

Stabilization of Knock Rating, Gums, and Color of Gasoline by Chemical Inhibitors. By Gustav Egloff, W. F. Faragher and J. C. Morrell. Paper presented at tenth annual meeting of the American Petroleum Institute, Chicago, Dec. 4, 1929. [G-1]

Tables and the accompanying explanation comprise the greater part of this paper, which reports the effects of storage on knock rating, gum content and color of various gasolines, and the effectiveness of certain chemical inhibitors in preventing and also restoring the antiknock and other characteristics of the fuels.

Two other papers dealing with this problem, which were presented at the meeting, are: Factors Affecting the Determination of Gum in Gasoline, by C. R. Wagner and Julius Hyman; and Some Phenomena of Gum Determinations in Motor Fuel, by E. C. Herthel and F. A. Apgar. In the former the authors describe a modification of the Smith and Cooke test for gum, in which the steam oven is replaced by an actively boiling water-bath. The copper-dish test is said to be unreliable, and, although no satisfactory stability test has as yet been developed, a hope is expressed for the development in the near future of such a method based on selective catalysts.

Herthel and Apgar investigate further the various gum-testing methods and report experiments which indicate that gum determinations by the copper-dish, the steam-oven and the oxygen-absorption methods, as practiced, cannot be correlated with one another or with the effect of storage, during which the acceleration of gum formation by light or by metal catalysis is possible. Furthermore, the authors point out, there may be other accelerators, such as moisture, which influences the prediction of commercial performance by laboratory test.

Proposed Standard Knock-Testing Engine Exhibited to A. P. I. By H. L. Horning. Published in *National Petroleum News*, Dec. 11, 1929, p. 37. [G-1]

This article is a news account quoting at length Mr. Horning's address before the annual meeting of the American Petroleum Institute in which he reviewed the history and present status of the detonation research project which is under the guidance of the Cooperative Fuel-Research Steering Committee and which has hitherto been reported in the Automotive Research columns of the S.A.E. JOURNAL.

The proposed standard knock-testing engine was exhibited at the meeting and described in detail by Mr. Horning.

Working Stresses for Steel at High Temperatures. By D. S. Jacobus. Presented at the annual meeting of the American Society of Mechanical Engineers, Dec. 2 to 6, 1929, New York City. [G-1]

Certain of the published results for the stress to produce creep at higher temperatures have led to apprehension in the employment of stresses that have been used, and the object of the author in preparing this paper was to dispel such apprehension for the particular stresses discussed.

The results secured in practical experience are used for setting the maximum working stresses up to temperatures of 800 deg. fahr., and for temperatures above 800 deg. fahr. the working stresses are scaled down in proportion to the falling off of the stresses that produce creep. The first curve of creep-points published by H. J. French, of the Bureau of Standards, was used, and the working stresses for a given temperature are taken at two-thirds the creep-point stress. The effect on the stress of piercing a boiler shell with holes and of transmitting heat through the shell is discussed, as is also the tendency toward equalization of stress through extension of the most-strained fiber. The tendency of the creep to equalize the stresses is also brought out.

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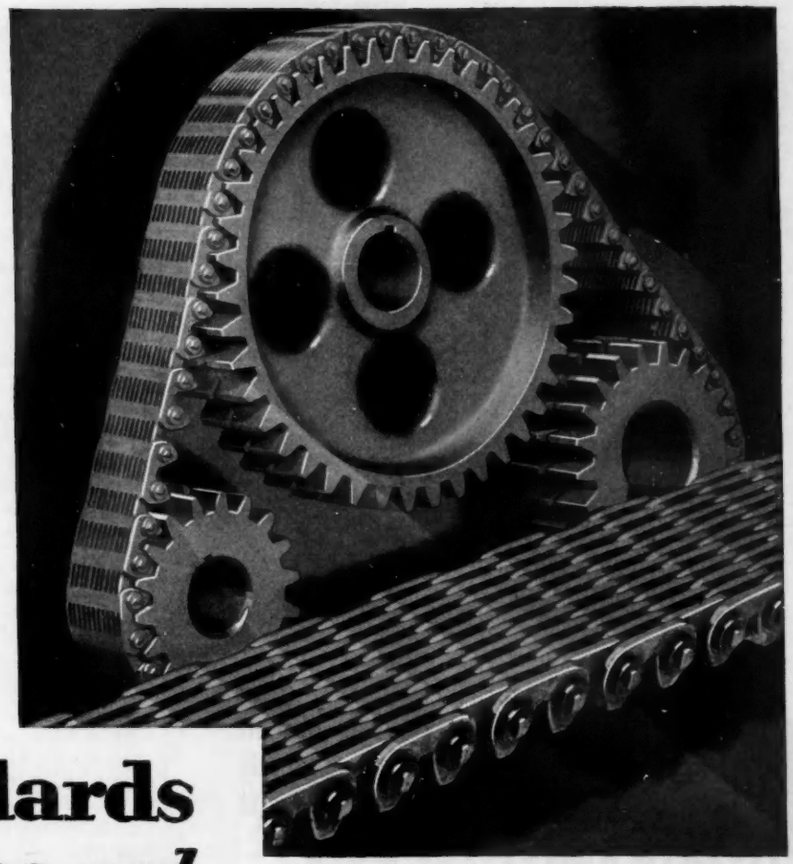

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Notes and Reviews

Continued

The method of extrapolation used by different authorities is discussed, and the conclusion is reached that more exact results are obtained by using the method employed by Prof. F. H. Norton, described in his book on the Creep of Steel at High Temperatures, than by some other methods.

A Directory of Research on Heat Transmission in the Educational Institutions of the United States and Canada. Second Edition, revised Nov. 25, 1929. Compiled by the Committee on Heat Transmission, Division of Engineering and Industrial Research, National Research Council, New York City, 1929; 36 pp. [G1]

This directory contains brief abstracts of the work on heat transmission in progress at the educational institutions of the United States and Canada. The inclusion of Canadian institutions is a feature of the second edition. Progress is recorded on the projects noted previously and new projects that have been undertaken are included.

A Study of Tin-Base Bearing Metals—II. By G. B. Karelitz and O. W. Ellis. Presented at the annual meeting of the American Society of Mechanical Engineers, Dec. 2 to 6, 1929, New York City. [G-1]

This paper is a continuation of one presented by the authors at the Pittsburgh meeting of the A.S.M.E. in 1928 and deals with the mechanism of wiping of babbitt linings, with certain phenomena observed during the casting of tin-base alloys, and with the effects of cold work on them. It is shown that wiping of babbitts is a result of the reaching of the solidus temperature by the upper layer of the lining; when the constituent with the lowest melting temperature liquefies, the babbitt becomes "mushy" and is therefore wiped by the journal. The appearance of castings of various chemical compositions is discussed, and the variation in hardness and microstructure due to cold work is given.

The Eutectic Composition of Copper and Tin. By G. O. Hiers and G. P. de Forest. Presented at the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, Cleveland, September, 1929. [G-1]

The object of this work, as stated by the authors, is to determine the eutectic composition of copper and tin and to determine the location of the part of the liquidus line immediately above the eutectic composition in copper. Three methods were used in the investigation: (*a*) dissolving copper in a bath of molten tin at constant temperature, with the idea that when the bath is saturated with copper its copper content, by analysis, together with the temperature at which the saturation occurs, will locate a point on the liquidus line; (*b*) the method of the differential cooling-curves; and (*c*) the method of miscroscopic examination.

This paper is principally concerned with the results of the last two methods mentioned. The results of the first method, that of dissolving copper in molten tin, did not agree with the results of Miller, by the same method, nor with the results of other investigators by other methods, nor yet with the results of the cooling-curve experiments and microscopic examination.

Recovery of Waste from Tin-Base Babbitting Operation. By P. J. Potter. Presented at the Institute of Metals Division of the American Institute of Mining and Metallurgical Engineers, Cleveland, September, 1929. [G-1]

Virtually all tin-base babbitt metals used in engine bearings are made to customers' specifications, which are many and varied, declares the author. The copper ranges from 3 to 8 per cent, and the antimony from 4 to 13 per cent; generally, the babbitt with lower copper-content will contain from 4 to 8 per cent antimony, and that with higher copper will have from 7 to 13 per cent antimony. The allowable lead-content varies from 0.20 to 2.00 per cent

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Notes and Reviews

Continued

If a solder is used as a bonding material instead of tin, the resulting material in the finished bearing will have a higher lead-content, but it would not be enough to bring the lead above specificational limits. Impurities in the tin, such as iron, arsenic and bismuth, should be determined before using to ensure a uniform and high-grade product. These points must be considered when segregating and grading the waste that comes from the finishing operations on lined bearings.

Steels for Automobiles and Aeroplanes. By W. H. Hatfield. Paper presented before a joint meeting of the Institution of Automobile Engineers and the Iron and Steel Institute, London, November, 1929. **[G-3]**

The author summarizes his experience in the study of the production and use of automobile and airplane steels during the years that have elapsed since the writing of his last previous paper on this subject in 1921. He classifies the various steels according to composition and discusses the specifications and uses of each group. This grouping includes ordinary carbon and alloy steels, valve and spring steels, those used for frames, bodies and tubular members, nitrided steels, and rustless and stainless steels.

Appendix 1 is a series of tables listing the parts of airplane engines, racing and passenger-car engines, and engines for heavy slow-speed vehicles, and giving the nature of the chief stresses produced in service, the intensity of service, the materials in use and those recommended.

A bibliography with abstracts of articles published on steels used in the automobile and airplane industries for the period 1921 to 1929, attached as Appendix 2 of the paper, adds considerable value.

MISCELLANEOUS

Le Dossier Technique S. I. A. By M. Dufresne. Published in the *Journal de la Société des Ingénieurs de L'Automobile*, November, 1929, p. 794. **[H-1]**

The French society of automotive engineers has made arrangements for a technical service intended for the use of engineers, designers, draftsmen and purchasing agents. It consists of making up and circulating loose-leaf booklets containing information on commercial products, parts and accessories. The leaves will be made up and distributed as often as is necessary to make the booklets complete and up-to-date. In general, the information will include all dimensions and details necessary to adapt the part to a vehicle. Manufacturers of the products covered will pay for the cost of printing the sheets, while the society will distribute the material, charging the subscribers with the cost of distribution.

Les Coussinets à Roulement sur Huile. By Ch. Dantin. Published in *Le Génie Civil*, Dec. 14, 1929, p. 587. **[H-1]**

This article treats theoretically of oil films in journal bearings. It outlines the general laws affecting the formation of oil films, differentiates between total and partial films in journal bearings, and considers separately concentric and eccentric bearings.

Welding and Cutting Nomenclature, Definitions and Symbols. Bulletin published by the American Welding Society, New York City, 1929; 43 pp. and index. **[H-5]**

This bulletin has been under preparation by the American Welding Society for the last three years and is both fundamental and comprehensive. It should go far toward standardizing the terminology in this field.

Under Nomenclature, in Section 1, the names of the principal welding processes are given in full, and a schematic diagram of the principal welding processes illustrates graphically their inter-relation. Section 2 embraces definitions of general welding terms, processes, forms of joint, forms of weld, and equipment and supplies. These definitions and the abbreviations in Section 3 are profusely illustrated. The symbols given in Section 4 are for use in connection with the resistance and fusion-welding processes.

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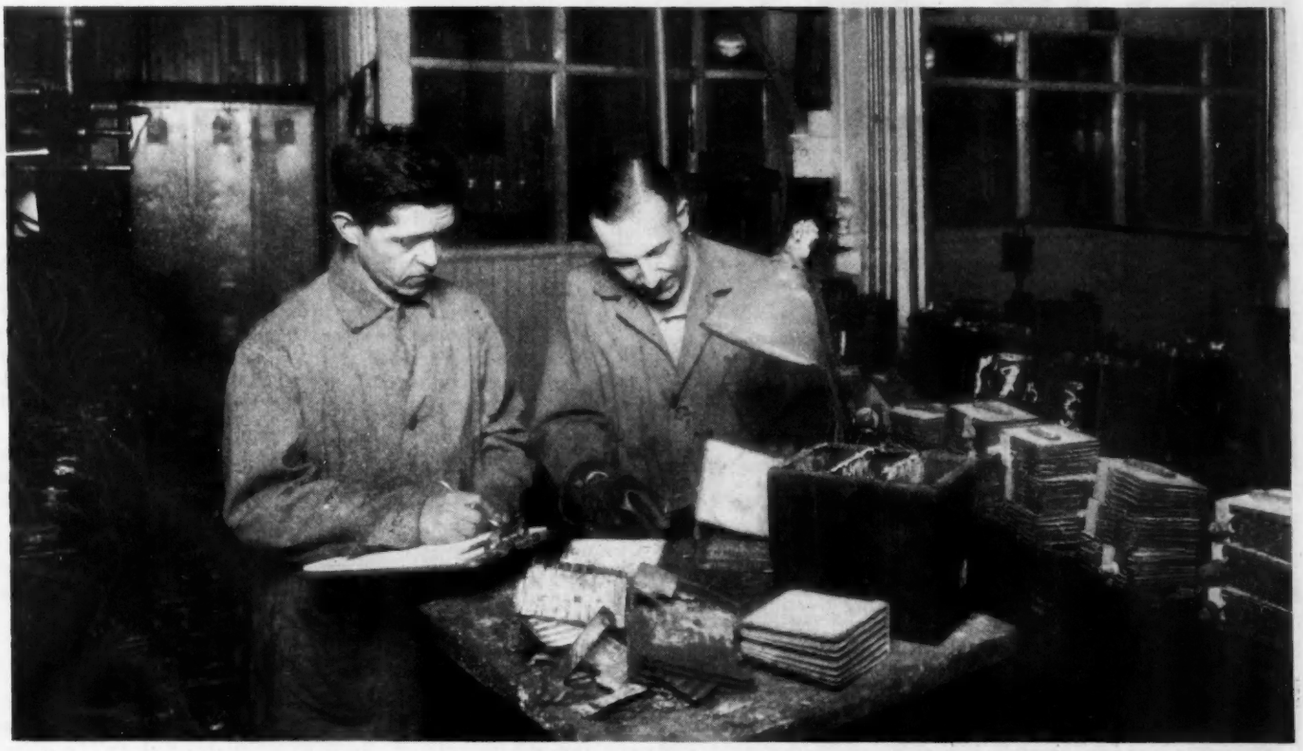

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Notes and Reviews

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Management of Service Departments—Budgeting and Wage Incentives Applied to a Large Organization. By William B. Ferguson and T. H. Blair. Presented at the annual meeting of the American Society of Mechanical Engineers, Dec. 2 to 6, 1929, New York City. [H-5]

The organization and the management of the service departments in a large plant spread over an area of 140 acres and having more than 6000 employes doing a great variety of unstandardized work of fluctuating volume present many difficult and complicated problems. After the productive or operative departments in the Newport News plant of the Shipbuilding & Dry Dock Co. had been reorganized and modern methods of planning, scheduling, production control, cost control, and wage-incentive plans had been put into effect over a period of about five years, it became possible to undertake further improvements in the staff and service departments with respect to better organization and the training of executives and employes, and the measuring in some way, directly or indirectly, of the value of the service rendered or the output of these service departments; and finally the applying of bonus plans or other wage-incentive schemes to reward the more than 700 men and women employes in these service departments for improved efficiency. The methods described are the result of preceding study and preliminary work for over a year and represent the simplest forms of wage incentive that seemed practicable to apply to a large plant of this character.

The main feature is that an opportunity could be and has been offered to all employes in all service departments for increasing their earnings in proportion to their results, thereby increasing the net earnings of the company to a much greater extent than has probably ever been appreciated. The authors state their belief that this is the first record of such an accomplishment in a very large industrial plant.

MOTOR TRUCK

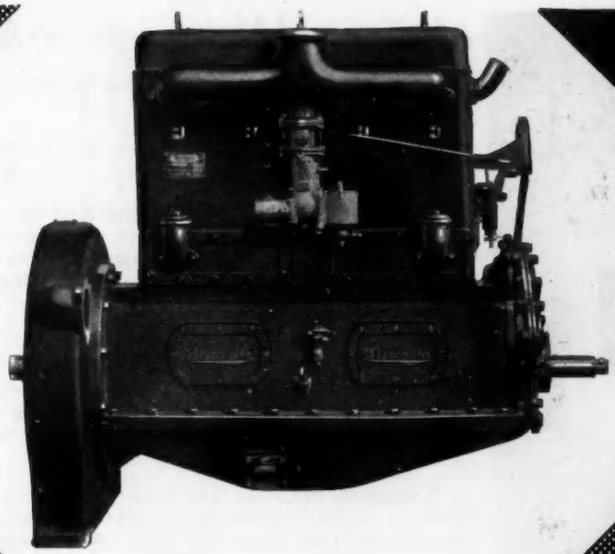
Le XXIII^e Salon de l'Automobile: Troisième Série, Véhicules Industriels. By G. Delanghe. Published in *Le Génie Civil*, Dec. 21, 1929, p. 605. [K-1]

In eight years the number of commercial vehicles in use in France has increased five-fold. At present, of every 100 vehicles manufactured, 22 are designed for industrial purposes, and of every 100 of the latter, 5 are small trucks, 7 are 3-ton, 6 are 4-ton, 11 are 5-ton trucks, and one is a tractor. Amplifying this statistical summary, the author goes into the manner of vehicle usage, emphasizing the increase in scheduled high-speed motorcoach and freight service.

Of the developments evidenced in the industrial section of the 23rd Paris Automobile Salon, the author mentions first the slow progress of the gas-producer, slow because few operators will accept the inconveniences attendant on a gas-producer installation. A continued application of the electric vehicle in service in which frequent stops are the rule, and a lack of change in the Diesel-engine situation, complete the summation so far as special-class vehicles are concerned.

In the gasoline-engined field, the author notes the uninterrupted growth in popularity of the six-cylinder engine, with one eight-cylinder job; higher vehicle and engine speeds, even up to engine speeds of 3000 r.p.m., with governors almost universally applied; virtual disappearance of the chain-drive transmission; growing utilization of six-wheel vehicles for 10 and 12-ton loads; substitution of pneumatic for solid tires; and the quest for greater riding-comfort.

Detailed descriptions of the principal exhibits complete the story of the show.



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MORE POWER per CUBIC INCH

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LAMINUM is composed of paper-thin sheets of durable shim brass held together by metallic binder. Shims of Laminum are *solid as a solid shim.* Surface is smooth as glass. Gauge always accurate. No filing. No time lost. Just peel off the layers to the right thickness and shim is ready for adjustment.

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Personal Notes of the Members

(*Continued from p.* 409)

to that he was chief chemist of the Plainfield Mfg. Corp., a division of the Spice Mfg. Corp., at South Plainfield, N. J.

George C. Davies, who is employed by the Vacuum Oil Co. of New York City, has been transferred to the Paulsboro, N. J., plant of that company, where he is assistant automotive engineer in charge of fuel testing in the research laboratory.

Raymond Wilson Dunster has recently left the United States to take up his work as an engineer for the Vacuum Oil Co. of South Africa, Ltd. He will be stationed at Cape Town, South Africa. Previous to making this connection, Mr. Dunster was an experimental engineer with the Timken-Detroit Axle Co. in Detroit.

Nathaniel Ely, who has been specializing in automotive patents in the United States Patent Office, has become a member of the patent law firm of Hammond & Littell, of New York City.

H. H. Emmons, now Police Commissioner of the City of Detroit, recently resigned as chairman of the board of directors of the Detroit Aircraft Corp., because his police duties require all of his time and attention.

R. A. Flum has been made factory manager for the National Automatic Tool Co. of Richmond, Ind. He was formerly manufacturing advisor to the receivers of the McMyler-Interstate Co. of Bedford, Ohio.

Richard W. Fulton is now general sales manager for the Consolidated Aircraft Co. of Buffalo. His previous connection was as director of sales for the Colonial Flying Service, of New York City.

John P. Gaty has relinquished his post as research engineer for the Acoustic Products Co., of New York City, to accept a similar position with the Hantra Co. of the same city.

Donat A. Gauthier, a former service engineer in the carbureter division of the Penberthy Injector Co. of Detroit, has accepted a similar position with the Zenith Detroit Corp. in Detroit.

William E. Gibbons, who was employed as a layout draftsman by Servel, Inc., of Evansville, Ind., recently left that position to become a designer for the Bendix Brake Co., in South Bend, Ind.

Lady Mary Heath has been elected a member of the board of directors of the Airways Corp. of America, of the City of Washington.

Otto C. W. Henze has severed his connection as chief engineer in the calculator division of the Allen-Wales Corp. of New York City, to become a mechanical engineer with the RCA-Victor Corp., of Camden, N. J.

Alf. Heum, a former aeronautical engineer for the Fairchild Airplane Mfg. Co. of Farmingdale, L. I., is now employed as draftsman and engineer by the Aircraft Products Corp. of Detroit.

Bennett Hill, who was engineer in charge of aviation-engine design with the Horace E. Dodge Boat Works, of Detroit, has been appointed chief engineer of the Dee Wite Boat Co. of River Rouge, Mich.

Theodore S. Johnson, who was employed in the refined-oil department of the Vacuum Oil Co., of New York City, as an automotive engineer, has been transferred and is now in the fuels department of that company at Cairo, Egypt.

Curtis W. Keegin, until lately sales manager of the shock-absorber division of the Continental Motors Corp. of Detroit, has entered the employment of the Spicer Mfg. Corp. in Detroit.

(*Continued on next left-hand page*)

The Curtiss Tanager, winner of the Daniel Guggenheim Fund prize for safety in aeronautics.

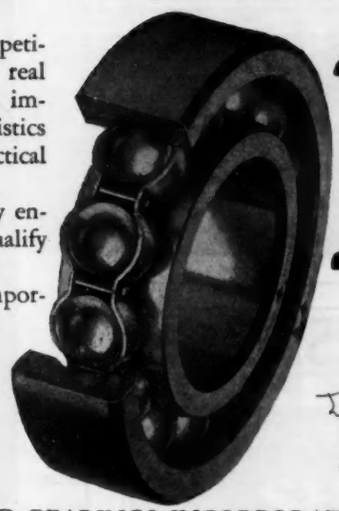
SRB BALL BEARINGS

in a Curtiss Challenger Engine Carried the Curtiss Tanager to Victory in the Daniel Guggenheim Safe Aircraft Contest

THE Guggenheim Safe Aircraft Competition was established "to achieve a real advance in safety of flying through improvement of aerodynamic characteristics without sacrificing the good, practical qualities of present day aircraft."

The Curtiss Tanager was the only entrant out of fifteen competitors to qualify on each factor of the competition.

SRB Ball Bearings have been an important factor in the successes of practically every prominent aircraft engine manufactured in America since the advent of aeronautics. This same dependable performance is equally valuable in the automotive industry.



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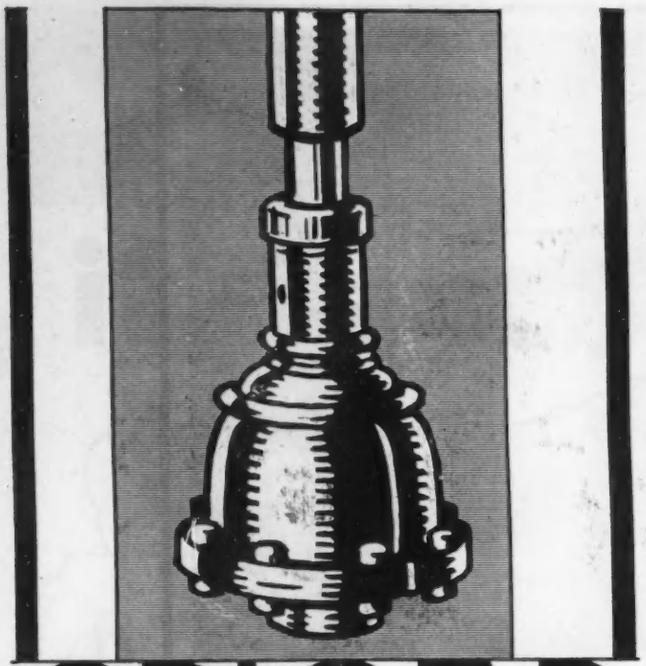

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FRAMES and STAMPINGS

SPICER MFG. CORP
TOLEDO OHIO
UNIVERSAL JOINTS

SPICER MFG. CORP
TOLEDO OHIO
SALISBURY AXLES

Personal Notes of the Members

Continued

R. J. Kelleher, who was vice-president and general manager of the North East Service, Inc., of Rochester, N. Y., is now affiliated with the overseas division of the General Motors Corp., of New York City.

C. F. Kettering, general director of the General Motors Corp. Research Laboratories of Detroit, and **J. W. Thomas,** vice-president of the Firestone Tire & Rubber Co. of Akron, Ohio, are two of ten members of a committee formed to select the citizen of the United States who in 1929 performed the most distinguished service for the advancement of social and economic welfare of the engineering profession and humanity at large. The originator of this award, which is in the form of a medal called the Henry W. Clausen Medal, is H. A. Wagner of Chicago. The medal is of gold and will be given annually hereafter by the American Association of Engineers.

R. Mack Krebs has joined the Chris Smith & Sans Boat Co. of Algonac, Mich., as service manager, having recently relinquished his post as a writer of technical service literature for the Graham-Paige Motors Corp. of Detroit.

Harry W. Lake, a member of the Materiel Division of the Army Air Corps at Wright Field, Dayton, Ohio, has been promoted from chief of the engine unit in the inspector's branch to principal aviation-engine inspector.

R. F. LaMothe, previously a member of the planning department of the Waukesha Motor Co. of Waukesha, Wis., is now sales manager for the American Metal Products Co. of Milwaukee.

John D. Lannon, formerly general superintendent of plants for the American Radiator Co. of New York City, was recently elected vice-president and general manager of the Brockway-Indiana Motor Truck Corp., also of New York City.

Raymond F. L'Ecruyer, a former laboratory assistant to Joseph Tracy of New York City, is now an experimental test engineer with the Wright Aeronautical Corp. of Paterson, N. J.

P. W. Litchfield, president of the Goodyear Tire & Rubber Co. of Akron, Ohio, has been appointed a member of the board of directors of the American Arbitration Association. He is the author of several papers which have appeared in publications of the Society.

William V. Logan is now connected with the petroleum industries division of the Boston Woven Hose & Rubber Co., with offices in New York City. Mr. Logan's former connection was with the United States Rubber Co., for which he was manager of distributors tire sales, with headquarters in New York City.

William P. MacCracken, Jr., has been elected chairman of the board of the New York, Rio & Buenos Aires Line, Inc., of New York City. Mr. MacCracken was, until recently, Assistant Secretary of Commerce for Aeronautics, in the Department of Commerce. A Personal Note reviewing his engineering career appeared in the S. A. E. JOURNAL for October, 1929, on p. 431.

A. K. Mackenzie has relinquished his post as service manager for the Massy Co., Ltd., of Trinidad, British West Indies, and is now connected with the Neal Engineering Co., Ltd., of Port of Spain, Trinidad.

Charles W. McKinley has been made assistant chief engineer for the A. C. Spark Plug Co. of Flint, Mich. He was formerly research engineer for that company.

Amos F. Meyer has relinquished the position as draftsman he held with the C. H. Will Motors Corp., of Minneapolis, to accept a similar post with the General Motors Truck Corp. of Pontiac, Mich.

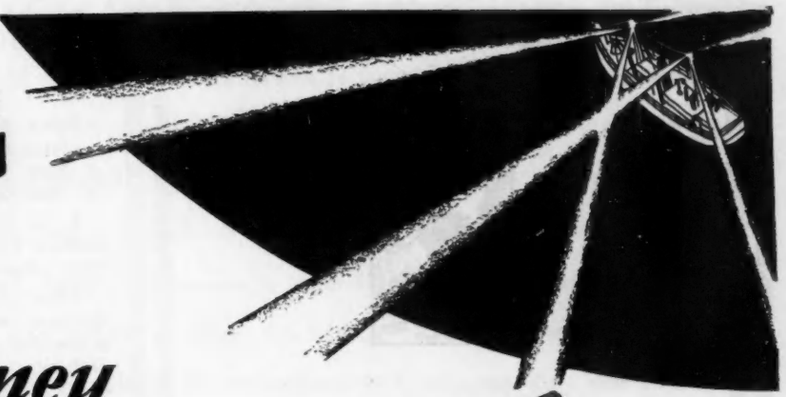
John William Mills has resigned as general manager of the Ascot Motor & Mfg. Co., Ltd., of Letchworth, England, but has not announced his plans for the future.

(*Continued on next left-hand page*)

SAVING LIVES

..... *and Money*

with Cummins Diesel Engines *and* NATIONAL SHIMS



NATIONALS are built like a writing pad, soldered at edge only, layers already separated for quicker, easier fitting—simply thumb 'em. Made of hard brass to resist bolt pressure—*thickness* constant. Individually miked at factory for greater, more uniform accuracy. With or without anchored Babbitt Tips (patd.) or anchored Babbitt Face (patd.)

LIFE-SAVING equipment *must* be DEPENDABLE. It must be proof against any and all emergencies. It must be quickly and easily *serviced* at all times and places. Blunt's Reef Lightship No. 100 shown above, is but one of a fleet of Pacific Coast Lightships equipped with *Cummins Diesel Engine Marine Auxiliaries.* And Cummins Engine Co. is but one of more than 50 Manufacturers now using NATIONAL *Double-action Non-curling* SHIMS. Whether your problem is saving lives or money, or both, you will find in NATIONALS *all* the advantages of *any* method PLUS many advantages obtainable by *no* other method. NATIONAL SHIMS are *different.* Write today for full facts. Engineering recommendations upon request. Submit blueprints for prices. You may be surprised.

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ST. PAUL—Merchants National Bank Building
ST. LOUIS—International Life Building
KANSAS CITY—Reliance Building

Personal Notes of the Members

Continued

Fritz Mitschke has recently become an inspector for machine-tools with the Amtorg, Stalingrad Tractor Division, of New York City. He was formerly a tool designer for the Waukesha Motor Co. of Waukesha, Wis.

J. D. Morello, transportation engineer for the General Motors Corp., has been transferred from the New York City office to the company's plant in Madrid, Spain.

Amos E. Northup has severed his connection as chief designer with the Willys-Overland Co. of Toledo, to accept a similar position with the Murray Corp. of America, of Detroit.

O. W. A. Oetting is now engineer of the Globe-Union Mfg. Co. of Milwaukee. His former position was that of chief engineer with the Willard Storage Battery Co. of Cleveland.

Clarence H. Osthagen, a recent graduate of the University of Kentucky, is now attending the school of architecture at Columbia University, where he is studying for his Master's degree.

George H. Palm recently became connected with the Young Radiator Co. of Racine, Wis., and is now in charge of engineering there. Latterly he was employed in the new-development division of the General Motors Truck Corp. of Pontiac, Mich.

R. J. S. Piggott, who until lately was consulting mechanical engineer for Stevens & Wood, Inc., of New York City, has been appointed chief of the engineering research department of the Gulf Production & Pipe Line Co. of Pittsburgh.

Paul R. Riess is now a member of the service division of the Franklin Motor Car Co. of Syracuse, N. Y., having previously held the position of service representative for the Reo Motor Car Co. of Lansing, Mich.

Walter C. Robbins has been elected vice-president in charge of engineering and manufacturing for the Gabriel Snubber Mfg. Co. of Cleveland, having been advanced from the post of chief engineer and factory manager.

A. M. Sargent recently resigned as vice-president in charge of engineering of the QC Engineering & Tool Sales of Detroit, and has accepted a position as general manager of the Michigan Machine Co. of the same city.

W. M. Scarth, formerly assistant specification engineer of the General Motors Co. of Oshawa, Canada, has severed that connection and is now assistant research engineer with the Auburn Automobile Co. of Auburn, Ind.

Herbert Scheel, who has been sales manager for the Ferguson Motor Co. of Dallas, Texas, is now connected with the Olds Motor Works branch in that city.

Albert L. Schoff, who is employed in the bus division of the General Motors Export Co. of New York City, has been transferred, and is now transportation engineer of the General Motors of Japan, Ltd., of Osaka, Japan.

Mario Scoles, a foreign member of the society, recently became assistant body engineer for the Fiat Motor Co. of Torino, Italy. He was formerly in the service of several leading American automobile manufacturers, his last American post having been with the Pierce-Arrow Motor Car Co., of Buffalo, which employed him as an automobile body draftsman.

Fred H. Sklenar, until lately a designer of carbureters for the Marvel Carbureter Co. of Flint, Mich., has accepted a position with the McAlear Mfg. Co. of Chicago.

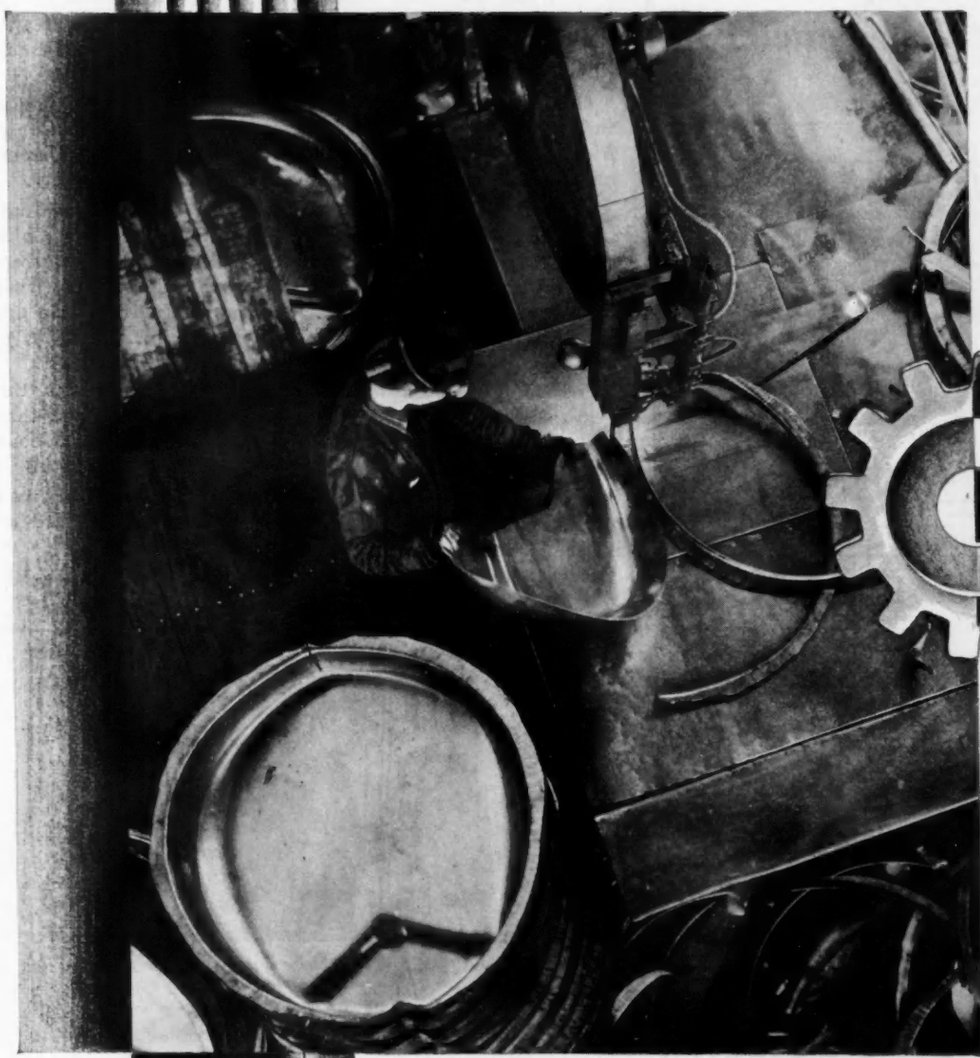
Clifford W. Smith is now employed as a body layout draftsman for the H. H. Franklin Mfg. Co. of Syracuse, having formerly served Dietrich, Inc., of Detroit, in a similar capacity.

Max W. Thaete, having resigned his post as service manager for Charles Schonlaw of Hollywood, Cal., is now employed in a similar capacity by the Jackson Chevrolet Co. of Pueblo, Col.

(*Concluded on next left-hand page*)

WHEN YOU PUT WORK IN THEIR HANDS

HIS HAT is old and dirty. His overalls would be the better for a week at the laundry. Streaks of grime brush over his face and up past a rather good forehead. By and large, you probably could not distinguish Pete among a hundred others. Yet this man is one of a chosen generation of Americans—men who hold more power under their hands than any other workers in history. He operates a machine! • The Clayton & Lambert Manufacturing Company has not been slow to recognize that with the coming of machines there must come also a higher standard of workmanship. Machines can do so much and no more; the men must work *with* them. We have the feeling that any metal stamping, whatever its nature, is the better because intelligent and accurate men are on the controlling end. • We endeavor to attract that type of workmanship . . . men with a feeling for machinery. You can rest assured that any work you may send here will be done well, and done quickly, by efficient, faithful workmen.



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AUTOMOBILE TRUCK TRACTOR AEROPLANE MISCELLANEOUS

Complete Heat Treating and Laboratory Facilities

Capacity 2500 Tons Per Month

Any Type—Any Size—Up to 500 Lbs.

UNION SWITCH & SIGNAL CO.

Drop Forge Division

SWISSVALE, PA.

Personal Notes of the Members

Concluded

George H. Townsend has announced his retirement from active business. He was formerly president of the Moto-Meter Co. and is a long-time member of the society, having been admitted in 1915.

T. J. Uilkema, designing engineer, recently became affiliated with Fairbanks, Morse & Co. of Beloit, Wis. His previous connection was with the General Motors Corp. of Detroit, in a similar capacity.

Ralph White, until recently a special engineer in the Detroit plant of the Budd Mfg. Co., has been transferred to that company's Philadelphia plant.

V. White has been made assistant district manager for the Autocar Sales & Service Co. of Philadelphia. He was until lately assistant sales manager for the LaFrance Republic Sales Corp. of New York City.

C. G. Williams has accepted a position as a designer in the experimental department of the Automatic Tool Co. of Richmond, Ind. He was previously employed by Cincinnati Grinders, Inc., of Cincinnati, in a similar capacity.

E. E. Wilson, who recently resigned his post as Commander, U. S. N., aviation aide to the Commander in Chief of the Battle Fleet in the City of Washington, is now president of the Hamilton Standard Propeller Corp. of West Homestead, Pa. A Personal Note regarding Mr. Wilson appeared in the January number of the S.A.E. JOURNAL p. 118.

"Dick" S. Woods, until lately chief engineer for the Craveroiler Co. of America in Philadelphia, resigned that post to enter the independent field as owner of the Woods Engineering Co. of Noble, Pa.

Orville Wright, consulting engineer of Dayton, Ohio, has been honored by the Daniel Guggenheim Medal Board of Award by having the first Daniel Guggenheim Medal bestowed upon him. The medal will be presented to Mr. Wright on April 8.

HAVE YOU A NEW ADDRESS?

If you have moved please notify the office of the Society so that you will not miss an issue of your Journal.